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THE SHOCK AND VIBRATION DIGEST

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THE SHOCK and VIBRATION DIGEST

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SVIC NOTES

Many interesting meetings relating to shock and vibration technology were held during 1984, and the two meetings that seemed the most interesting to me were the Second International Modal Analysis Conference and the Vibration Damping Workshop. Both of these meetings interested me because they revealed possible new directions for controlling noise and vibration; but more to the point, they represent growing branches of interest in the shock and vibration technology in the sense of greater involvement on the part of the shock and vibration technical community.

Fortunately, I was able to attend the Modal Analysis and Test Conference, and this meeting was reviewed in the April, 1984, issue of the **Shock and Vibration Digest**. Judging by the papers that were presented in that conference, modal analysis and testing is still a popular topic, and for many reasons. Modal analysis and testing is a dynamic field since new techniques are constantly being developed. New and unusual modal testing requirements often arise, and these often lead to some interesting questions. For example, the question of how to conduct a modal test at frequencies approaching 100 kHz arose in the panel session at the Modal Analysis Conference. The subject of modal testing and analysis appeals to a widely diverse group of users who routinely use it to solve noise and vibration problems; the diversity in the users seems to be increasing. And finally, possible new directions in modal testing and analysis cannot be ignored; detecting damage in structures from the changes in their modal properties is a good example.

Judging from the program of the Vibration Damping Workshop, this conference provided a broad snapshot of the damping technology, from characterizing the properties of damping materials to integrating damping treatments into the product design at an early stage. This latter topic represents a new direction in the use of the damping technology for controlling noise and vibration, and I believe the literature published on damping during 1984, and perhaps the past few years, has stressed this new direction in controlling noise and vibration. An effect of this recently published literature on damping will be to make a broader segment of the shock and vibration technical community aware of advances in the damping technology. But more important, it will provide them with the tools for preventing noise or vibration problems in future systems.

R.H.V.

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J.W.

EDITORS RATTLE SPACE

CRITERIA AND STANDARDS

Any person performing a test on new or old equipment recognizes the need for criteria, guidelines, and standards. A number, waveform, or spectrum alone means little when assessing the quality of equipment. Standards provide the mechanism for the use of techniques and methods in acquiring and processing data in a common manner. They establish the process that permits data taken by different investigators to be compared. It is an essential step in forming criteria and levels so desperately needed in the vibration field. I feel that the development of acceptable levels of vibration for equipment is one of immediate challenges of the vibration field.

Even though millions of vibration measurements are being made every year, acceptable levels of vibration are available for only general classes of equipment and special types of excitation. In the case of rotating machinery, vibration levels are available for general equipment for once-per-revolution frequency vibrations. These numbers provide guidelines for engineers but are not useful in assessing the severity of critical vibration problems. The data needed to develop detailed vibration criteria are being gathered. Unfortunately they are used only for the immediate task at hand.

The major reason data are not retained in a useful form is cost. Up to this time it was too costly to record and transmit data to a data bank. The advent of the microprocessor based devices has changed this situation. If data are taken according to standard guidelines it appears that they could be transmitted to a data bank with little extra cost to the plant. These data could be merged with those taken in other plants to provide the large sample needed to develop acceptable vibration levels for specific equipment. All engineers in the present and future would benefit from such a program -- similar to that sponsored by the U.S. Navy to develop balancing levels.

While the aforementioned type program has yet to be established on an ongoing basis, there are many organizations including American National Standards Institute involved in the development of standards. Many trade associations and societies such as the American Petroleum Institute and the Society of Automotive Engineers are heavily involved in this work. I suggest those interested in the future of standards and criteria contact one of the organizations and spend some effort on this important work. If you need direction in where to focus your efforts, call me at the Vibration Institute.

R.L.E.

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APPLICATIONS OF THE CONFORMAL MAPPING
METHOD TO THE SOLUTION OF MECHANICAL
VIBRATIONS PROBLEMS

P.A.A. Laura*

Abstract. Traditional applications of the method of conformal mapping are governed by the Laplace equation. However, in recent years the equation has also been used to solve wave propagation problems and those involving membrane and plate vibrations. In many instances it has been possible to obtain elegant approximate analytical solutions and algorithmic procedures; they have been implemented on desk computers and programmable pocket calculators.

Most graduate engineers have learned that conformal mapping makes exact analytical solutions possible for two-dimensional boundary value problems governed by the Laplace equation:

$$\nabla^2 \phi = 0 \tag{1}$$

In some cases no solution could have been obtained otherwise because of the complexity of the given domain.

Application of the conformal mapping technique is straightforward for problems described by the Laplace equation provided the analytic function that performs the desired mapping is known. Determination of the mapping function is usually a very difficult task [1, 2]. But the partial differential equation is invariant under transformation.

In graduate courses on the mathematical theory of elasticity [3, 4] conformal mapping is usually applied to the solution of free torsion of prismatic rods governed by Poisson's equation

$$\nabla^2 \phi = -2G\theta \text{ (a constant)} \tag{2}$$

and to the plane elastic problem when equation (3) is to be solved.

$$\nabla^4 U = 0 \tag{3}$$

Solutions to equations (2) and (3) are considerably more difficult than is solving equation (1) because equations (2) and (3) do not remain invariant under transformation.

It is of historic interest that stress concentration factors in civil, mechanical, naval, and aeronautical structural systems were determined in many instances in the 1940s and 1950s using this approach. Early in the 1960s the first mathematical models of solid propellant rocket grains were analyzed; the conformal mapping method was used to transform the doubly connected cross section (circular region with a star-shaped perforation) into a circular annulus.

It is the object of this paper to present a brief survey of applications of the conformal mapping method to vibration problems involving rods, plates, and membranes. Conformal mapping has also been used recently to study the vibration characteristics of helicopter airframes. It is also of interest that conformal mapping [5, 6] can be used to solve many steady- and non-steady-state heat conduction problems in nuclear reactor technology.

SOLUTION OF THE HELMHOLTZ EQUATION
CONFORMAL MAPPING

Small amplitude vibrations of an ideal membrane are governed by the classical, two-dimensional wave equation

$$\nabla^2 v = \frac{1}{c^2} \frac{\partial^2 v}{\partial t^2} \tag{4}$$

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subject to the boundary condition

$$v[L(x, y) = 0, t] = 0 \qquad (5)$$

$L(x, y) = 0$ is the functional relation that defines the boundary of the domain.

In the case of normal modes

$$v(x, y, t) = V(x, y) e^{i\omega t} \qquad (6)$$

Substitution of this relationship in equations (4) and (5) results in a time independent differential system.

$$\nabla^2 V + \left(\frac{\omega}{c}\right)^2 V = 0 \qquad (7a)$$

$$V[L(x, y) = 0] = 0 \qquad (7b)$$

Equation (7a) is the well known Helmholtz equation; it also governs other phenomena of fundamental importance such as wave propagation in hollow-piped electromagnetic and acoustical waveguides. The boundary condition in equation (7b) governs the propagation of TM waves and acoustical waves in soft walls.

For TE waves and in the case of acoustically hard waveguides equation (7b) is replaced by the Neuman-type boundary condition

$$\frac{\partial V}{\partial n} [L(x, y) = 0] = 0 \qquad (7c)$$

where n is the outer normal to the domain.

If the domain is natural to one of the common coordinate systems for which (7a) can be solved by the classical method of separation of variables, solutions are available in standard textbooks. For more complicated domains approximate techniques must be used.

However, when the analytic function that transforms the given domain in the z-plane onto a simpler one in the ξ-plane, say a unit circle, is known (see Figure 1).

$$z = x + iy = f(\xi) \qquad (8)$$

Equation (7) can then be transformed to obtain

$$\nabla^2 V + \left(\frac{\omega}{c}\right)^2 \left|f'(\xi)\right|^2 V = 0 \qquad (9a)$$

$$V(r, \theta)\Big|_{r=1} = 0 \qquad (9b)$$

or

$$\frac{\partial V}{\partial r}(r, \theta)\Big|_{r=1} = 0 \qquad (9c)$$

Equation (9a) is more complicated than (7a), but the transformed differential system has an inherent advantage: the geometry of the domain is such that the boundary condition can be identically satisfied. Many approximate analytical procedures are now available; e.g., Galerkin, Ritz, [7].

Consider, for instance, the case of a membrane with rounded corners [8] (see Figure 2) with

$$z = f(\xi) = aL(\xi + \epsilon \xi^5), \ L = 25/24, \ \epsilon = -1/25 \qquad (10)$$

Make

$$V(r, \theta) \cong b_1(1-r^2) + b_2(1-r^4) \qquad (11)$$

a) Physical Plane
Membrane of Complicated
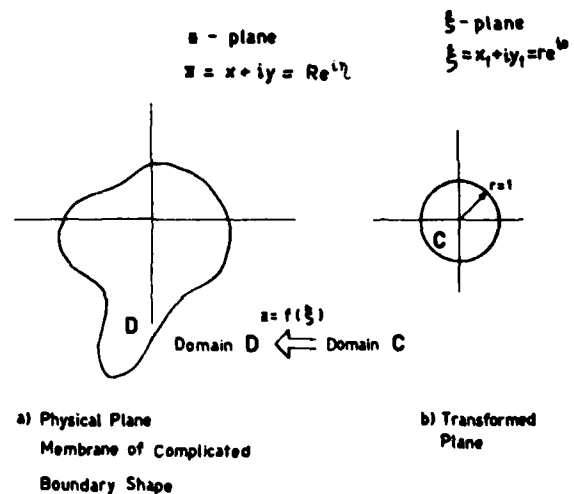Boundary Shape

b) Transformed Plane

Figure 1. Conformal Mapping of a Given, Complicated Domain

Use the Galerkin method to obtain for the fundamental frequency coefficient

$$\omega_{01} \frac{a}{c} = 2.308$$

This value is in remarkably good agreement with another determined value [8].

Other studies dealing with vibrations of membranes are available in the literature [9]. The case of a composite membrane has been dealt with [10], as have electromagnetic waveguides [11-18] and acoustical waveguides [19-23]. The first analytical studies on simple mathematical models of vibrating solid propellant rocket motors were also based on the conformal mapping approach [24-26].

VIBRATIONS OF PLATES

In many cases printed circuit boards possess non-rectangular and non-circular shapes (see Figure 3a). Regular polygonal shapes with concentric circular perforations (Figure 3b) are of interest in nuclear reactor technology. Several studies have dealt with vibrating plates of complicated boundary shape [27-30]. Some work [31-34] has taken into account in-plane forces and the presence of concentrated masses.

SOUND RADIATION STUDIES

The conformal mapping method has been used in the study of sound radiation phenomena. Particularly valuable is a study due to Berger [36], who ob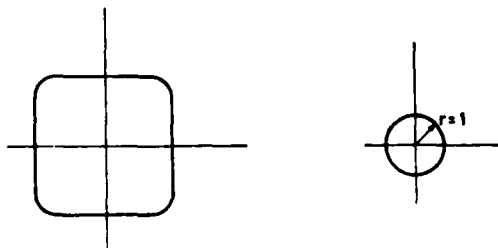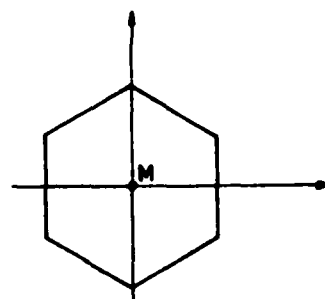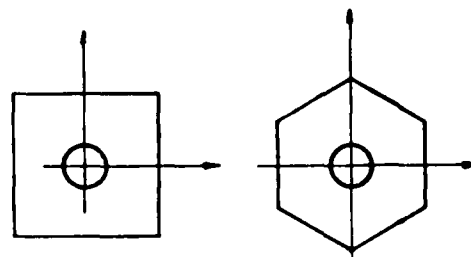tained a numerical solution for the transient vibration of an arbitrary shell of revolution surrounded by an acoustic medium. The region external to the generating curve of the shell was mapped conformally onto the region external to the unit circle.

VIBRATIONS OF HELICOPTER AIRFRAMES

Bartlett [37] recently developed an interesting method to evaluate the effect of structural changes on the vibration characteristics of helicopter airframes. He assumed that the mass and stiffness matrices of the damped linear structure are real and symmetrical and that the damping matrix is symmetrical and positive definite. He also assumed that the changes made to the structure do not affect applied vibrational loads. He provided expressions for the vibration response of the airframe at a point in terms of mobilities. The author proved that the responses map onto circles in the complex plane and that the vector from the origin of the complex plane to a point on the circumference defines the magnitude and phase of the response for a particular structural mobility.

a) Printed Circuit Board of Hexagonal Shape Carrying a Concentrated Mass

b) Nuclear Reactor Elements of Regular Polygonal Shape With a Concentric Circular Perforation

Figure 2. Square Membrane with Rounded Corners

Figure 3. Modern Applications of Conformal Mapping

CONCLUSIONS

Modern technology requires solutions for a never-ending number of problems in which the domain has a complicated geometry. The conformal mapping method provides an accurate and rather simple way to solve a large number of problems in many fields. Furthermore, in many instances it provides for an independent check for large computer-oriented solutions. Many of the results contained in the scientific literature quoted in this paper have been obtained using a microcomputer or a pocket programmable calculator.

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the litera-
ture, consists of two to four review articles each month, 3,000 to 4,000 words in
length. The purpose of this section is to present a "digest" of literature over a
period of three years. Planned by the Technical Editor, this section provides the
DIGEST reader with up-to-date insights into current technology in more than
150 topic areas. Review articles include technical information from articles, reports,
and unpublished proceedings. Each article also contains a minor tutorial of the
technical area under discussion, a survey and evaluation of the new literature, and
recommendations. Review articles are written by experts in the shock and vibration
field.

This issue of the DIGEST contains an article about machine tool vibrations.

Dr. V. Ramamurti and Mr. D. Ganapathi Rao of the Department of Applied Me-
chanics, Indian Institute of Technology, Madras, India have written a review of
work done on machine tool vibrations and noise since 1981.

MACHINE TOOL VIBRATIONS -- A REVIEW

V. Ramamurti* and D. Ganapathi Rao**

Abstract. The material reported here is work done on machine tool vibrations and noise since 1981.

CHATTER IN MACHINE TOOLS

A major topic of interest is chatter in machine tools. The general concept of machine tool chatter has been discussed [1], as have methods adopted for reducing it [2]. It was concluded [2] that the continuous fluctuating cutting speed of machine tools partly reverses the chatter causing function. A unified systems approach for chatter analysis has been presented [3]. A theoretical approach for predicting chatter has been verified experimentally by turning a slender bar on a turret lathe [4]. Milling machine chatter has been a subject of discussion [5], as has chatter in lathes including general characteristics of chatter vibration [6] and the mechanism of exciting energy supply [7].

The conclusion after an experimental study of carbide face milling cutters was that increased tool wear due to vibration is governed mainly by the *stiffness of certain elements in the cutting mechanism* [8]. A distinction has been made between the vibration of a cutting tool and its resulting cutting marks [9]; the cutting marks are not a simple reproduction of the vibration. Two basic experiments have shown that certain machining operations result in a single change of cutting parameters that permanently *eliminates regenerative chatter vibration* [10].

Self-excited oscillations of machine tools have been studied [11-15]. A relation between fluctuations of rotational speed of a workpiece and frequencies of self-excited oscillations has been reported [11]. An adaptive control of the cutting process including *self-excited oscillation has been the subject of a study* [12]. Stick slip motion due to low driving speed has been reported [13]. Material parameters of a work-piece that affect self-induced oscillation have been determined [14]. Vibrations of a forced self-excited system with time lag have been examined, as has the influence of *initial conditions on steady-state behavior* [15].

GENERAL DYNAMIC ANALYSIS

Dynamic analysis and optimal selection of parameters of a lathe spindle under random cutting loads have been undertaken [16]. Free vibration behavior of lathe spindles has been studied [17]. A general vibration study has been used to diagnose the health of a machine [18]. A minicomputer has been used to determine the frequency response of machine tools [19]. Effects of machine vibrations on the accuracy and quality of machine parts have been evaluated [20].

Methods have been developed to study static and dynamic behaviors of machine tools [21]. A test procedure for vibration analysis has been developed to check a machining setup [22]. Experiments have been conducted on the nonlinearity of cutting forces [23]. Stability of machine tools under regenerative cutting conditions has been studied [24]. Instrumentation for testing the vibration stability of machine tools in shop conditions has been reported [25]. Discussions on the dynamic stability of a vibrating hammer are available [26].

Static stiffness of machine tool spindles has also been a subject of discussion [27]. Dynamic stiffness of machine tool feed systems has been presented in a theoretical analysis [28]; an experimental evaluation of damping capacity has been done [29]. The use of preloaded bearings to maximize the dynamic stiffness has been discussed [30].

Modal analysis of machine tool structures based on experimental data has been reported [31, 32]. A

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new method for altering natural frequencies to maximize intervals between adjacent frequencies has been developed [33], as has a new mathematical model of the dynamic characteristics of machine structures [34]. The dynamics of metal cutting have been discussed [35, 36], as have the vibration and stability of band saws [37, 38] and the dynamic design of machine tool foundations [39].

Classical techniques and the dynamic data system (DDS) approach have been compared for accuracy in identifying the structural systems of machine tools [40]. The DDS approach has been applied to the analysis of dynamic characteristics of a machine tool system in the time domain. Impulse responses have been applied to machine tool structures to identify vibration characteristics [42]. A mathematical model of the structural dynamics of a machine tool with nonproportional viscous damping effect has been developed using the method of state space vector analysis [43]. New parameters for evaluating static rigidity and dynamic characteristics for optimizing the structural design of machine tools under different type of cutting arrangements and operations have been identified [44].

A comparative study of dynamic characteristics using hydraulic and epoxy resin concretes for machine tool structures showed that epoxy resin concrete had better characteristics than hydraulic concrete [45]. A method for determining the rigidity coefficient and the damping of flexible elements of machine tool drives has been proposed [46].

An expression for determining the amplitude-phase frequency relationship of an elastic system of a machine tool during cutting was based on information about relative tool and workpiece vibrations [47]. A method for the structural improvement of machine tool vibration stability during cutting has been proposed [48], as has a method for estimating the mean square frequency and using it to reduce the amplitude and frequency of a near-periodic signal to a single variable [49]. An algorithm of a program for calculating the vibration stability of boring units has been proposed [50]; suggestions for utilizing the results to improve the quality of the equipment being designed were also indicated. A mathematical description and analysis of the rotational accuracy of a machine tool spindle have been presented [51].

NOISE IN MACHINE TOOLS

The noise and vibration produced by workshop machinery has been surveyed [52], and recommendations for noise abatement of machines have been given [53]. The design of low noise machine tools [54], and noise abatement in the development of manufacturing concepts [55] have been discussed. Structure-borne noise in machine tools has been presented in a linear model [56]. A novel damper for reducing tool noise has been proposed [57]. It has been shown that the noise level of a machine can be predicted at the design stage [58, 59]. Computer-aided design in predicting a sound field has been described [60]. Current methods for monitoring noise generation have been surveyed [61], and results of the design of a jumbo drill have been summarized [62]. Test data have been used to discuss the effect of increased noise on cutting force and temperature [63]. It has been shown that the noise level distribution of various machine concentrations cannot be described simply by summing up sound levels from individual plants and machine tools [64].

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BOOK REVIEWS

DISCRETE FOURIER TRANSFORMATION AND ITS APPLICATIONS TO POWER SPECTRA ESTIMATION

C. Geckinli and D. Yavuz
Studies in Electrical and Electronic Engineering 8,
Elsevier Publishing Company, New York, NY
1983, 340 pages, $78.75

This book is the culmination of a seven year effort that began with lecture notes used in preliminary form at the Moore School of Electrical Engineering of the University of Pennsylvania, other universities, seminars, and training programs. The authors concentrate on the discrete Fourier transform (DFT), its most efficient computerized version of the fast Fourier transform (FFT), and the application of these methods to power spectra estimation.

In the first chapter the authors present a concise yet comprehensive introduction to the Fourier transformation. This chapter constitutes a review of relevant terminology and concepts that form the basis for the remainder of the text. It is not intended to replace standard books on the subject but to set the stage and provide a brief guided tour of the subject so that the presentation is self-contained.

The second chapter introduces the DFT and develops the FFT as a technique for calculating DFT coefficients most efficiently. The third chapter comprises half of the main body of the text and covers in considerable detail the subject of power spectra estimation through DFT techniques. The material on data and spectral methods is new and instructive. A great deal of this exposition appears for the first time in a textbook.

A significant feature of this book is Appendix B. It contains 14 complete examples with actual input data and output for a wide range of signal types. These examples provide actual numerical results that illustrate the effects of changing sampling rates and input/output data intervals. This is an excellent supplement to the application-oriented information and program listings throughout the book.

Despite the fact that the FFT has been around for about 20 years, not many textbooks have been devoted to it. A notable exception is the book by E.O. Brigham, published by Prentice-Hall in 1974. It is indeed fortunate that within a period of another decade an excellent book containing the application of the FFT to power spectra estimation has appeared. It would be most desirable to decrease the sampling time of these milestones in textbook writing to half its current interval.

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INTER-NOISE '83
NOISE CONTROL: THE INTERNATIONAL SCENE

R. Lawrence, Editor
Noise Control Foundation, Poughkeepsie, NY
1983, 1242 pages, $72.00

This two-volume set is the proceedings of the 1983 International Conference on Noise Control Engineering that took place in July, 1983, in Edinburgh, Scotland. Sponsored by the International Institute of Noise Control Engineering, the Conference was jointly organized by the Institute of Acoustics of the United Kingdom and the Fellowship of Engineering.

The Inter-Noise proceedings have always been characterized by a large number of short papers covering an extremely wide range of subject areas related to sound and vibration. This conference was no exception and consisted of nearly 300 technical papers. International participation has also been a hallmark

of the Inter-Noise conferences and the international theme was duly reflected by authors representing 28 countries.

One cannot easily generalize on the technical quality of these proceedings due to the number of contributions and the wide variety of subject areas included. This reviewer has often felt that the Inter-Noise Series would benefit from a reduction in the number of papers and a corresponding increase in the detail of those papers retained. However, in many of the more technically sophisticated papers, references to previously published works partially compensate for the lack of detail.

A particularly valuable feature of the Inter-Noise Proceedings is the Distinguished Lecture Series, wherein a number of recognized authorities present overviews of their areas of specialization. These overviews are oriented toward the general acoustics/ noise control practitioner and often include historical background notes to illustrate significant developments that have led to the present state of the art. Selected titles of this series are "Effects of Vibrations on Humans," "Acoustic Consultancy," and "The Acoustical Design of Concert Halls," and the 1983 Rayleigh Medal Lecture by Eugen Skudrzyk, "Understanding the Dynamic Behavior of Complex Vibrators."

Among the wide variety of subject areas covered by the conference papers can be identified groups of papers devoted to specific subjects in which strong research and development efforts have recently been concentrated. Active sound control is certainly an example with 16 very interesting contributions. A number of these contributions are based on impressive results produced by the Wolfson Centre for the Electronic Cancellation of Noise and Vibration at Essex University, U.K.

Marine applications of noise and vibration control are also a dominant theme. Five papers were related to off-shore platforms, and another five had to do with surface vessels.

In the area of probability analysis applied to traffic noise and transmission loss of building structures was a series of eight papers co-authored by M. Ohta of Hiroshima University. These contributions are characterized by a degree of mathematical sophistication

beyond that usually found in the Inter Noise Conference proceedings.

A prime source of technical papers since the inception of the Inter-Noise Conferences has been the propagation of sound in air and the effects of ground surfaces, barriers, and turbulence. In this Conference, we again find a substantial number of contributions of both a theoretical and a practical nature.

In summary, this well-organized publication offers a wealth of subject matter to the noise/vibration specialist and the beginner as well. Indeed, it would be difficult to find an active worker in the field who could not find something of interest in these proceedings.

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TIME SERIES AND SYSTEM ANALYSIS WITH APPLICATIONS

S.M. Pandit and S.M. Wu
John Wiley & Sons, New York, NY
1983, 586 pages

Engineers now consider time series as the response of a system that can be modeled with increasing degrees of freedom when the data justify it. The method of least squares is used to improve the fit until it is statistically significant. As stated by the authors, "The new modelling strategy can greatly reduce the tedious chore of searching for an appropriate model . . . This book will bring together time series and systems analysis to provide . . . specialists with a new tool . . . make time series analysis useful to engineers and scientists. This book is application oriented . . . both stochastic and deterministic approaches are presented." This procedure has been applied to machine tools, systems analysis, nuclear power plant surveillance, vibration analysis, and biomedical engineering.

The book contains 11 chapters and an elaborate appendix including computer programs. Chapter 1

introduces time series: correlation, regression, dynamics, stochastic difference/differential equations, and applications. The next chapter covers autoregressive moving average models (ARMA) in detail. Topics include simple and multiple regression models, first order autoregression models such as random walk, second order ARMA -- also designated ARMA (2, 1) -- a nonlinear model of ARMA (2, 1), and least square estimates in simple and multiple regressions. Chapter 3 describes characteristics of the ARMA model including Green's function, implicit and explicit ARMA (2, 1) systems in terms of Green's function, and higher order ARMA models; i.e., ARMA (m, n). The next section discusses autocovariance functions as applied to AR (1), MA (1), and ARMA (2, 1) models as well as the relationship between Green's function and the autocovariance function. The concluding section is a short discourse on partial autocorrelation and autospectrum applied to ARMA models.

The next chapter has to do with modeling. Topics include dynamics, autocovariance, adequacy of the system approach, estimation of AR and ARMA models, checks of adequacy utilizing the statistical approach of F criterion, and checks on residual autocorrelations. Examples are given of a grinding wheel profile and mechanical vibration data using a higher order ARMA model, i.e., ARMA (6, 5).

Chapter 5 reports on forecasting and includes prediction as an orthogonal projection using AR (1) models and the general ARMA (n, m) model as examples. Other topics are exponential smoothing and relationship with ARMA and comparisons among Weiner-Kolmogorov prediction theory, ARMA models, and exponential smoothing.

The following chapter has to do with the uniform sampling of continuous systems. First order differential equations, Dirac delta functions, first order autoregressive system A (1), the standard stochastic differential equation, a uniformly sampled first order system, and limitations of the sampling interval and autocovariance function are described.

Chapter 7 reports on second order systems and random vibration. Differential equations for a damped spring-mass-system, the second order autoregressive system A (2), uniformly sampled second order autoregressive systems, and regions of static and dynamic stability are described. The concluding sections cover the A (2) model from discrete data, including spectral estimation and the effects of sampling interval, natural frequency, and damping. Examples considered are profile model characterization of a grinding wheel and experimental verification of a proposed ARMA model and true value. The reviewer believes that this method will be most used in random vibration theory, response spectra analysis, and experimentation applied to random vibration analysis.

The next chapter is concerned with the AM (2, 1) model and its application to exponential smoothing. Chapter 9 treats stochastic trends and seasonality with application to money market rates, investment modeling, and modeling of consumer and wholesale price indices.

The tenth chapter focuses on deterministic trends, seasonality, and nonstationary series including linear trends with crack propagation as an example. For the data used the deterministic data have the greatest influence. However, the reviewer believes that more extensive studies of crack propagation data will indicate that the stochastic part will exert a greater influence. Other topics are exponential trends employing first order dynamics and differential equations, periodic trends, and general nonstationary models.

The topic of the last chapter is multiple series. This encompasses transfer functions, ARMA including velocity (i.e., ARMAV), examples, optimal control employing minimum mean squared error control strategy, effects of a large lag, and forecasting by leading indicators. The appendices include normal distribution, chi square, t, and F distribution tables.

This is a different book. The reviewer believes that a table of nomenclature would be an added feature for the reader. Matrix methods, although mentioned, should be expanded and applied to time series analysis. Time series will become more important in testing. It should be slanted toward modal analysis and important fluid-structure aspects of data analysis.

H. Saunders
1 Arcadian Drive
Scotia, NY 12302

SHORT COURSES

JANUARY

RELIABILITY METHODS IN MECHANICAL AND STRUCTURAL DESIGN

Dates: January 7-11, 1985
Place: Tucson, Arizona

Objective: The objective of this short course and workshop is to review the elements of probability and statistics and the recent theoretical and practical developments in the application of probability theory and statistics to engineering design. Special emphasis will be given to fatigue and fracture reliability.

Contact: Special Professional Education, Harvill Bldg., Box 9, College of Engineering, University of Arizona, Tucson, AZ 85721 - (602) 621-3054.

FEBRUARY

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: February 4-8, 1985
Place: Santa Barbara, California
Dates: March 11-13, 1985
Place: Washington, D.C.
Dates: May 6-10, 1985
Place: Boston, Massachusetts
Dates: June 3-7, 1985
Place: Santa Barbara, California
Dates: August 26-30, 1985
Place: Santa Barbara, California

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos Street, Santa Barbara, CA 93105 - (805) 682-7171.

MACHINERY VIBRATION ANALYSIS

Dates: February 19-22, 1985
Place: Tempe, Arizona
Dates: August 13-16, 1985
Place: Nashville, Tennessee
Dates: October 29 - November 1, 1985
Place: Oak Brook, Illinois

Objective: This course emphasizes the role of vibrations in mechanical equipment, instrumentation for vibration measurement, techniques for vibration analysis and control, and vibration correction and criteria. Examples and case histories from actual vibration problems in the petroleum, process, chemical, power, paper, and pharmaceutical industries are used to illustrate techniques. Participants have the opportunity to become familiar with these techniques during the workshops. Lecture topics include: spectrum, time domain, modal, and orbital analysis; determination of natural frequency, resonance, and critical speed; vibration analysis of specific mechanical components, equipment, and equipment trains; identification of machine forces and frequencies; basic rotor dynamics including fluid-film bearing characteristics, instabilities, and response to mass unbalance; vibration correction including balancing; vibration control including isolation and damping of installed equipment; selection and use of instrumentation; equipment evaluation techniques; shop testing; and plant predictive and preventive maintenance. This course will be of interest to plant engineers and technicians who must identify and correct faults in machinery.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MARCH

PENETRATION MECHANICS

Dates: March 18-22, 1985
Place: San Antonio, Texas
Objective: This course presents the fundamental

principles of penetration mechanics and their application to various solution techniques in different impact regimes. Analytical, numerical, and experimental approaches to penetration and perforation problems will be covered. Major topic headings of the course are fundamental relationships, material considerations, penetration of semi-infinite targets, perforation of thin targets, penetration/perforation of thick targets, hydrocode solution techniques, experimental techniques. Discussions will include such topics as fragment or projectile breakup, obliquity, yaw, shape effects, and richochet. Shock propagation, failure mechanisms and modeling, constitutive relations, and equation-of-state will be presented in the context of penetration mechanics. Developed fundamental relationships will be applied in the following areas: hypervelocity impact, long rod penetration; spaced and composite armors, explosive initiation, hydrodynamic ram, fragment containment, earth penetration, crater/hole size, spallation, shaped charge penetration.

Contact: Ms. Deborah J. Stowitts, Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78284 - (512) 684-5111, Ext. 2046.

VIBRATION CONTROL
Dates: March 25-29, 1985
Place: Manassas, Virginia
Dates: June 3-7, 1985
Place: San Diego, California
Objective: This vibration control course will include all aspects of vibration control except alignment and balancing. (These topics are covered in separate Institute courses.) Specific topics include active and passive isolation, damping, tuning, reduction of excitation, dynamic absorbers, and auxiliary mass dampers. The general features of commercially available isolation and damping hardware will be summarized. Application of the finite element method to predicting the response of structures will be presented; such predictions are used to minimize structural vibrations during the engineering design process. Lumped mass-spring-damper modeling will be used to describe the translational vibration behavior of packages and machines. Measurement and analysis of vibration responses of machines and structures are included in the course. The course emphasizes the practical aspects of vibration control. Appropriate

case histories will be presented for both isolation and damping.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MODAL TESTING OF MACHINES AND STRUCTURES
Dates: March 26-29, 1985
Place: Manassas, Virginia
Dates: August 13-16, 1985
Place: Nashville, Tennessee
Objective: Vibration testing and analysis associated with machines and structures will be discussed in detail. Practical examples will be given to illustrate important concepts. Theory and test philosophy of modal techniques, methods for mobility measurements, methods for analyzing mobility data, mathematical modeling from mobility data, and applications of modal test results will be presented.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MAY

ROTOR DYNAMICS
Dates: May 6-10, 1985
Place: Syria, Virginia
Objective: The role of rotor/bearing technology in the design, development and diagnostics of industrial machinery will be elaborated. The fundamentals of rotor dynamics; fluid-film bearings; and measurement, analytical, and computational techniques will be presented. The computation and measurement of critical speeds vibration response, and stability of rotor/bearing systems will be discussed in detail. Finite elements and transfer matrix modeling will be related to computation on mainframe computers, minicomputers, and microprocessors. Modeling and computation of transient rotor behavior and non-linear fluid-film bearing behavior will be described. Sessions will be devoted to flexible rotor balancing including turbogenerator rotors, bow behavior, squeeze-film dampers for turbomachinery, advanced concepts in troubleshooting and instrumentation,

and case histories involving the power and petro-chemical industries.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

OCTOBER

VIBRATIONS OF RECIPROCATING MACHINERY

Dates: October 29 - November 1, 1985
Place: Oak Brook, Illinois.
Objective: This course on vibrations of recipro-cating machinery includes piping and foundations. Equipment that will be addressed includes recipro-cating compressors and pumps as well as engines of all types. Engineering problems will be discussed from the point of view of computation and measure-ment. Basic pulsation theory -- including pulsations in reciprocating compressors and piping systems -- will be described. Acoustic resonance phenomena and digital acoustic simulation in piping will be reviewed. Calculations of piping vibration and stress will be illustrated with examples and case histories. Tor-sional vibrations of systems containing engines and pumps, compressors, and generators, including gear-boxes and fluid drives, will be covered. Factors that should be considered during the design and analysis of foundations for engines and compressors will be discussed. Practical aspects of the vibrations of reciprocating machinery will be emphasized. Case histories and examples will be presented to illustrate techniques.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

Announcement

2nd NATIONAL CONFERENCE AND WORKSHOP ON TAILORING ENVIRONMENTAL STANDARDS TO CONTROL CONTRACT REQUIREMENTS
June 24-26, 1985
Leesburg, Virginia

The Second National Conference and Workshop on Tailoring Environmental Standards to Control Contract Requirements will be held June 24-26, 1985 at the Xerox Facility in Leesburg, Virginia. This meeting is sponsored by the Institute of Environmental Sciences.

For further information contact: Institute of Environmental Sciences, 940 E. Northwest Highway, Mt. Prospect, Illinois 60056 - (312) 255-1561.

Announcement

19th MIDWESTERN MECHANICS CONFERENCE
September 9-11, 1985
Columbus, Ohio

The Nineteenth Midwestern Mechanics Conference will be held September 9-11, 1985 at The Ohio State University, Columbus, Ohio. Midwestern Mechanics Conferences have been held every two years since 1949. The program will consist of keynote and invited lecturers, as well as contributed papers. Contributed papers are solicited in all areas of mechanics.

For further information contact: Dr. A.W. Leissa, Department of Engineering Mechanics, Ohio State University, 155 W. Woodruff Avenue, Columbus, Ohio 43210 - (614) 422-2731.

ABSTRACTS FROM
THE CURRENT LITERATURE

ABSTRACT CONTENTS

AVAILABILITY OF PUBLICATIONS ABSTRACTED

None of the publications are available at SVIC or at the Vibration Institute, except those generated by either organization.

Periodical articles, society papers, and papers presented at conferences may be obtained at the Engineering Societies Library, 345 East 47th Street, New York, NY 10017; or Library of Congress, Washington, D.C., when not available in local or company libraries.

Government reports may be purchased from National Technical Information Service, Springfield, VA 22161. They are identified at the end of bibliographic citation by an NTIS order number with prefixes such as AD, N, NTIS, PB, DE, NUREG, DOE, and ERATL.

Ph.D. dissertations are identified by a DA order number and are available from University Microfilms International, Dissertation Copies, P.O. Box 1764, Ann Arbor, MI 48108.

U.S. patents and patent applications may be ordered by patent or patent application number from Commissioner of Patents, Washington, D.C. 20231.

Chinese publications, identified by a CSTA order number, are available in Chinese or English translation from International Information Service, Ltd., P.O. Box 24683, ABD Post Office, Hong Kong.

When ordering, the pertinent order number should always be included, not the DIGEST abstract number.

A List of Periodicals Scanned is published in issues, 1, 6, and 12.

22

MECHANICAL SYSTEMS

An extensive search was made of existing experiments and calculations based on the various prediction methods were made. This study shows that present analyses are adequate to predict the spectra from a wide variety of experiments on fans, full-scale and model-scale helicopter rotors, wind turbines, and propellers to within about 5 to 10 dB. Better knowledge of the inflow turbulence improves the accuracy of the predictions.

ROTATING MACHINES
(Also see Nos. 2743, 2796)

84-2630

Broadband Rotor Noise Analyses

A.R. George and S.-T. Chou

Cornell Univ., Ithaca, NY, Rept. No. NASA-CR-3797, 98 pp (Apr 1984)

N84-22365

Key Words: Rotors, Noise generation

The various mechanisms which generate broadband noise on a range of rotors studied include load fluctuations due to inflow turbulence, turbulent boundary layers passing the blades' trailing edges, and tip vortex formation. Existing analyses are used and extensions to them are developed to make more accurate predictions of rotor noise spectra and to determine which mechanisms are important in certain circumstances. Calculations based on the various prediction methods in existing experiments were compared. The present analyses are adequate to predict the spectra from a wide variety of experiments on fans, full scale and model scale helicopter rotors, wind turbines, and propellers to within about 5 to 10 dB.

84-2631

Comparison of Broadband Noise Mechanisms, Analyses, and Experiments on Rotors

A.R. George and S.-T. Chou

Cornell Univ., Ithaca, NY, J. Aircraft, 21 (8), pp 583-592 (Aug 1984) 15 figs, 58 refs

Key Words: Rotors, Noise generation, Turbulence, Vortex shedding

A study is made of the various mechanisms which generate broadband noise on a range of rotors. The sources considered are load fluctuations due to inflow turbulence, turbulent boundary layers passing the blades' trailing edges, and tip vortex formation. Vortex shedding noises due to laminar boundary layers and blunt trailing edges are not considered as they can be prevented in most cases. Various prediction methods have been reviewed and extended in some cases.

84-2632

Finite Element-Integral Acoustic Simulation of JT15D Turbofan Engine

K.J. Baumeister and S.J. Horowitz

NASA Lewis Res. Ctr., Cleveland, OH 44135, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 405-513 (July 1984) 14 figs, 2 tables, 22 refs

Key Words: Turbofan engines, Simulation, Finite element technique, Noise prediction, Engine noise

An iterative finite element integral technique is used to predict the sound field radiated from the JT15D turbofan inlet. The sound field is divided into two regions: the sound field within and near the inlet which is computed using the finite element method and the radiation field beyond the inlet which is calculated using an integral solution technique. The velocity potential formulation of the acoustic wave equation was employed in the program.

84-2633

Experimental Measurement of Alford's Force in Axial Flow Turbomachinery

J.M. Vance and F.J. Laudadio

Texas A&M Univ., College Station, TX 77843, J. Engrg. Gas Turbines Power, 106 (3), pp 585-590 (July 1984) 18 figs, 6 refs

Key Words: Turbomachinery, Force measurement, Fluid-induced excitation, Experimental data

This paper presents the results of experimental measurements made on a small, high-speed, axial-flow test apparatus to verify the existence of Alford's force and to investigate the validity of his mathematical prediction model. The measurements show that the cross-coupled aerodynamic force is linearly proportional to rotor eccentricity and to stage torque, as predicted by Alford's theory. However, it was found that the force is also speed-dependent, and that the inlet flow conditions to the stage have a pronounced effect.

84-2634

Flight Effects on Fan Noise with Static and Wind-Tunnel Comparisons

J.S. Preisser and D. Chestnutt
NASA Langley Res. Ctr., Hampton, VA, J. Aircraft, 21 (7), pp 453-461 (July 1984) 17 figs, 25 refs

Key Words: Turbofan engines, Turbofans, Fans, Noise generation, Flight simulation, Aircraft noise

A flight test program utilizing a JT15D-1 turbofan engine has been conducted with the objective of studying flight effects on fan noise and evaluating the simulation effectiveness of both a wind-tunnel and a static test configuration incorporating an inlet control device (ICD). In conjunction with synchronized laser-radar tracking and meteorological profile information, data obtained from a linear array of ground microphones were narrowband-analyzed and ensemble-averaged to yield highly accurate far-field flight acoustic results. Utilizing appropriate corrections, flight, wind-tunnel, and static acoustic data were normalized to a static-equivalent, 100-ft radius, lossless reference condition. Data comparisons showed that both the static test with ICD and wind tunnel were generally very effective in simulating flight blade-passage-frequency noise levels.

84-2635

Vane Stagger Angle and Camber Effects in Fan Noise Generation

J.B.H.M. Schulten
National Aerospace Lab., NLR, Amsterdam, The Netherlands, AIAA J., 22 (8), pp 1071-1079 (Aug 1984) 7 figs, 7 refs

Key Words: Fan noise, Noise generation, Ducts, Vanes

The problem of sound generated by the interaction of velocity disturbances with stator vanes in an annular duct is considered theoretically. The duct carries a uniform subsonic main flow and is assumed to be anechoic. In this problem it seems consistent to model the vanes by flat plates parallel to the duct axis. However, this modeling may yield an unrealistically low acoustic power. In the present paper a nonplanar lifting surface approximation of the vanes shows that at frequencies prevailing in current turbofans even a small vane inclination significantly affects the sound generation process.

84-2636

Reduction of Discrete Frequency Noise in Small, Subsonic Axial-Flow Fans

J.M. Fitzgerald and G.C. Lauchle
Pennsylvania State Univ., Box 30, State College, PA 16804, J. Acoust. Soc. Amer., 76 (1), pp 158-166 (July 1984) 13 figs, 2 tables, 21 refs

Key Words: Fans, Noise reduction, Electronic test equipment

The discrete frequency noise radiated from representative types of axial-flow fans used in electronic equipment is studied in detail. Narrow-band analysis of the discrete frequency noise radiated by these types of fans has been conducted in an anechoic environment. The farfield sound pressure level and radiated directivity of the discrete frequency noise are presented. The influence of operating condition on the radiated sound is determined.

84-2637

Aerodynamic Far Field Noise in Idling Circular Sawblades

C.D. Mote, Jr. and Wen Hua Zhu
Univ. of California, Berkeley, CA 94720, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 441-446 (July 1984) 7 figs, 12 refs

Key Words: Saws, Circular saws, Blades, Noise generation

The acoustic pressure radiated to the far field from dipole sources at the rim of a rotating circular sawblade is investigated theoretically and experimentally. Scattering from the sawblade surfaces and the presence of dipole source components in both the normal and radial coordinate directions explain the observed directivity and the dependence of the sound pressure upon sawblade rim velocity.

84-2638

Vortex Shedding: The Source of Noise and Vibration in Idling Circular Saws

M.C. Leu and C.D. Mote, Jr.
Cornell Univ., Ithaca, NY 14853, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 434-440 (July 1984) 13 figs, 1 table, 15 refs

Key Words: Saws, Circular saws, Noise generation, Vibration generation, Vortex shedding

Vortices separating from the edges of cutting teeth were shown to be the dominant source of pressure fluctuation

and hence noise in circular saws. Measurements of pressure on the surfaces of the blade and teeth showed: strong periodicity of the pressure on the tooth lateral surfaces, a 180 degree phase difference between the pressure variations on both tooth lateral surfaces, and pressure variations dominantly occurring on the tooth surfaces rather than the blade surfaces. The presence of an afterbody, downstream of the blade and tooth edges of flow separation, was found necessary for significant aerodynamic excitation of the blade and generation of noise by the flow.

METAL WORKING AND FORMING

84-2639
Means for the Reduction of Machine Tool Noise (Wege zur Geräuschminderung an spanenden Werkzeugmaschinen)
M. Klocker
VDI-Z., 126 (10), pp 345-351 (May 1984) 11 figs, 10 refs
(In German)

Key Words: Machine tools, Noise reduction, Design techniques, Finite element technique, Computer programs

The concept of noise reduction of machine tools should be integrated into the construction stage and improvements carried out on the finished equipment. The paper describes possibilities for the analysis of noise generation and the appropriate means for attacking the problem. One of such means is finite element technique combined with a digital computer program. The theoretical results are confirmed by means of a silent machine tool gear and a gear box.

84-2640
Self-Excited Chatter and Its Marks in Turning
T. Kaneko, H. Sato, Y. Tani, and M. O-Hori
Inst. of Industrial Science, Univ. of Tokyo, 22-1, Roppongi 7 chome, Minato-ku, Tokyo, Japan, J. Engrg. Indus., Trans. ASME, 106 (3), pp 222-228 (Aug 1984) 20 figs, 16 refs

Key Words: Chatter, Lathes, Machine tools

Investigations were made on self-excited chatter of the work which is held at one end on a lathe machine. Analysis was carried out by a two-degrees-of-freedom system. It was verified that introduction of the multiple regenerative effect governs the finite amplitude of the vibration after it is

excited. It was also shown that behavior of the work displacement rotating around the origin during the vibration could be explained by taking into account a resistive force which is inversely proportional to the cutting speed and is proportional to the velocity of the vibration. Phase difference of the vibration occuring for each turn of the work was measured by making use of a microcomputer system.

84-2641
Buckling Loads and Natural Frequencies of Drill Bits and Fluted Cutters
E.B. Magrab and D.E. Gilsinn
National Bureau of Standards, Washington, DC 20234, J. Engrg. Indus., Trans. ASME, 106 (3), pp 196-204 (Aug 1984) 10 figs, 17 refs

Key Words: Drills, Buckling, Natural frequencies, Mode shapes, Beams

The buckling loads, natural frequencies and mode shapes of twist-drill bits and certain fluted cutters under a variety of combinations of twist angle, cross-section geometry, and axial loading have been obtained. The drill bit is modeled as a twisted Euler beam under axial loading that is clamped at both ends. The governing system of differential equations is solved by the Galerkin procedure. Explicit forms for the basis functions used to generate the Galerkin coefficients are presented in general form in an appendix. They may be used for obtaining numerical results for that class of problems which use the Rayleigh-Ritz-Galerkin methods with beam-type functions as the basis functions.

MATERIALS HANDLING EQUIPMENT

84-2642
Accidental Loads in Crane Girders: A Case Study
A.J. Reis, C.S. Oliveira, and J.R.T. Azevedo
Tech. Univ. of Lisbon, Portugal, ASCE J. Struc. Engrg., 110 (7), pp 1679-1686 (July 1984) 7 figs, 3 refs

Key Words: Girders, Cranes (hoists)

The case of a crane transporting a large mass suspended by two sets of cables is considered. The dynamic behavior and the forces induced in the crane, due to the failure of one of the hanging mechanisms, are studied using two 3 degrees of freedom mathematical models. The highly nonlinear differential equations of motion are derived and integrated

by Runge-Kutta algorithm. The influence of the stiffness of the cables, the initial configuration of the system, the value of the hanging force corresponding to the cable release, and the stiffness of the braking system of the trolley are analyzed.

STRUCTURAL SYSTEMS

BRIDGES

84-2643
Role of Indicial Functions in Buffeting Analysis of Bridges
R.H. Scanlan
Princeton Univ., Princeton, NJ 08544, ASCE J. Struc. Engrg., 110 (7), pp 1433-1446 (July 1984) 2 figs, 30 refs

Key Words: Bridges, Flutter, Wind-induced excitation

The problem of the wind buffeting of bluff bodies, in this *instance bridge decks, is reexamined* from the standpoint of linearized theory. The links of flutter derivatives to aerodynamic indicial functions are first recalled and extended. The possibility that these functions offer of simplifying investigative aerodynamic tests of bridge models is discussed. The gust response problem is set up for a two-dimensional model in the time domain, employing aerodynamic indicial functions. A theoretical framework is offered for future wind tunnel model investigations under turbulent flow.

84-2644
Earthquake Response Analysis of Cable-Stayed Bridges under the Action of Travelling Waves
Xiang Haifan
J. of Tung-Chi Univ., (2), pp 1-9 (1983)
CSTA No. 624-83.107

Key Words: Bridges, Cable-stayed structures, Phase effects, *Earthquake response, Seismic response, Modal analysis*

The influence of the phase-different effect on earthquake response of a bridge is analyzed. The equation of motion of a cable-stayed bridge under non-coherent excitation of supports is derived using the matrix of influence function.

Through modal analysis, the modal participation factor and the modal ground acceleration in consideration of the phase-different effect are obtained, so that the influence of the phase-different effect can also be judged in a response spectrum of this modal ground acceleration.

BUILDINGS

84-2645
Circu-Rectangular Bundled Tube Office Tower – A Case History
J.S. Notch
Ellisor & Tanner, Inc., Houston, TX, ASCE J. Struc. Engrg., 110 (7), pp 1598-1612 (July 1984) 12 figs

Key Words: Buildings, Multistory buildings, Towers, Wind-induced excitation

This paper documents the structural design and analysis as it evolved in the planning of a new office tower. Aeroelastic wind tunnel models predicted that extreme dynamic oscillation of the tower may occur due to the configuration of existing tall buildings surrounding the site. Dynamic wind force resistance for the silver reflective glass structure was provided by a four-celled bundled framed tube system. The bundled tube frames are comprised of two-story high tree column modules located at 15 ft on centers around the building perimeter. The interior tubular cell partitions are framed by three tree beam diagonal truss frames quadsecting the tower's curvirectangular plan shape.

TOWERS
(See No. 2645)

FOUNDATIONS
(Also see Nos. 2759, 2760)

84-2646
Effect of Embedment on Foundation-Soil Impedances
A.N. Lin and P.C. Jennings
California Inst. of Tech., Pasadena, CA, ASCE J. Engrg. Mech., 110 (7), pp 1060-1075 (July 1984) 7 figs, 3 tables, 36 refs

Key Words: Interaction: soil-foundation, Mechanical imped-ance, Buildings

A 10-ft square, one-story model structure was subjected to horizontally incident SH-waves to determine the effect of foundation embedment on the response. Structural and foundation-soil impedances were calculated from the funda-mental resonant frequency and mode shape. The resulting impedance values and embedment factors were then com-pared to theoretical values. The translatory and rocking impedances for the unembedded case were found to be in agreement with values obtained from analytical formulations.

84-2647

Dynamics of Structures on Two-Spring Foundation Allowed to Uplift
C.-S. Yim and A.K. Chopra
Univ. of California, Berkeley, CA, ASCE J. Engrg. Mech., $\underline{110}$ (7), pp 1124-1146 (July 1984) 7 figs, 10 refs

Key Words: Foundations, Rigid foundations, Elastic supports

The dynamics of structures with their foundation mat supported only through gravity and thus permitted to uplift from the supporting system, are investigated. In its fixed base condition the structure is idealized as a single-degree-of-freedom system attached to a rigid foundation mat, which is supported at each edge by a spring-damper element. Ana-lytical expressions are presented for the free vibration re-sponse of the system and the effects of foundation uplift are examined. An effective numerical procedure, based on expressions of the Rayleigh-Ritz concept, to evaluate the structural response to earthquakes, is presented.

84-2648

Use of Ritz Vectors in Wave Propagation and Foun-dation Response
E.P. Bayo and E.L. Wilson
Univ. of California, Berkeley, CA, Earthquake Engrg. Struc. Dynam., $\underline{12}$ (4), pp 499-505 (July/Aug 1984) 3 figs, 4 tables, 6 refs

Key Words: Foundations, Wave propagation, Finite element technique, Ritz method

The accuracy of a numerical method is demonstrated for the dynamic analysis of large complex finite element systems in which the spatial distribution of the loading is constant. The method is based on the use of a special class of Ritz vectors which were previously proposed and can be generated with

minimum numerical effort. The purpose of this paper is to extend the use of these vectors to the solution of wave propagation and foundation response problems. The method is applied to one-, two- and three-dimensional problems.

84-2649

Running Stability of Large Rotor Bearing Founda-tion Models (Laufstabilitaet grosser Rotor-Gleitlager-Fundament-Konstruktionen)
D. Bosin
Technische Univ., Berlin, Fed. Rep. Germany, Rept. No. ILR-MITT-124/1983, 71 pp (1983)
N84-21887
(In German)

Key Words: Foundations, Machine foundations, Bearings, Rotors, Stability, Finite element technique

A finite element model of large turborotors including stiff-ness and damping of bearings and foundation and rotor stiffness was developed. A modal condensation procedure was employed to reduce substructure unknowns and the stability limit was iterated by eigenvalue computation. Threshold speed and unstable eigenfrequency was calcu-lated for a system of 16 reduced degrees of freedom (rotor-bearing model) and for a system of 46 reduced degrees of freedom (rotor-bearing-foundation model). The influence of rotor mass and stiffness, oil film stiffness and damping, Sommerfeld number, types of journal bearings, and mass, stiffness, and damping of the foundation was studied.

84-2650

Lateral Response of a Single Pile in Overconsolidated Clay to Relatively Low Frequency Harmonic Pile-Head Loads and Harmonic Ground Surface Loads
G.W. Blaney
Ph.D. Thesis, Univ. of Houston, 505 pp (1983)
DA8408976

Key Words: Pile structures, Clays, Harmonic excitation

The results of horizontal harmonic pile-head load tests on a single 10-inch diameter steel pipe pile imbedded in stiff over-consolidated clay are presented. The measured response of the pile to harmonic ground-surface loads is also pre-sented. The dynamic response of the instrumented pile cap, pile, and surrounding soil were recorded on a high-resolu-tion 60-channel digital recording system, and transfer func-tions were computed between the input loads and all instru-ment locations by a software system developed specially for the project.

84-2651

Laboratory Investigation of Vibratory Compaction of Dry Soils

C.R. Webster

Army Military Personnel Ctr., Alexandria VA, 118 pp (May 1984)
AD-A140 218

Key Words: Soils, Vibratory techniques

In arid regions where water may not be available for standard field compaction operations, compaction of soils at low moisture contents may be necessary. To determine whether these cohesive and cohesionless soils can be adequately compacted in a dry state, a laboratory vibratory soil compactor was built and used to conduct the investigation. After analyzing the effects of frequency of vibration, acceleration, static weight, and moisture content on compaction, a comparison of the unit weights obtained by standard and vibratory methods was made.

HARBORS AND DAMS

84-2652

Effect of Artificial Gaps on the Dynamic Behaviours of Dams

Zhou Jing, et al

China Civil Engrg. J., 16 (3), pp 33-44 (1983)
CSTA No. 624-83.119

Key Words: Dams, Discontinuity containing media, Natural frequencies

The frequency drop in free vibration of an elastic structure after artificial gapping is demonstrated. A simplified method -- ascending the matrix order and perturbation -- is proposed to determine the free vibration characteristics of an elastic structure with and without gaps. Numerical examples calculating the free vibration characteristics of a gapped gravity dam and an arch dam are given.

84-2653

On Free Liquid Oscillations in Irregular Basins

H.M. Safwat

Univ. of Alexandria, El-Hadrah, Alexandria, Egypt, ASCE J. Engrg. Mech., 110 (7), pp 1147-1160 (July 1984) 18 refs

Key Words: Dams, Sloshing, Geometric imperfection effects, Fundamental frequency

Complex variable methods have been devised to investigate the effect of geometric irregularities on the dynamic characteristics of inviscid liquids in circular basins. The fundamental frequency of the slosh mode has been determined by the stationary property of Schwarz quotients. Lower and upper bounds for the frequency have been obtained by a comparison theorem. Results show that frequencies are decreased with the increase of out-of-roundness parameters.

CONSTRUCTION EQUIPMENT
(See No. 2651)

POWER PLANTS
(Also see No. 2702)

84-2654

Investigation of the Earthquake Behavior of the Research Reactor FRJ-2 (Dido)

J. Altes, H. Graffi, and D. Koschmieder

Inst. fuer Nukleare Sicherheitsforschung, Kernforschungsanlage Juelich GmbH, Fed. Rep. Germany, Rept. No. JUEL-SPEZ-222, 26 pp (Oct 1983)
N84-22047

Key Words: Nuclear reactors, Earthquake response

Finite element calculations were carried out for the reactor FRJ-2 in order to determine its integrity after an earthquake. Results indicate a displacement of 5 mm occurring during 0.25 g safe shutdown earthquake for the reactor block in the horizontal and vertical directions, and 16 mm for the craneway in the horizontal direction, but without danger for the primary circuit.

84-2655

The Generation of Spectrum Compatible Accelerograms for the Design of Nuclear Power Plants

A. Preumont

Belgonucleaire, Rue du Champ de Mars, 25 1050, Brussels, Belgium, Earthquake Engrg. Struc. Dynam., 12 (4), pp 481-497 (July/Aug 1984) 9 figs, 1 table, 56 refs

28

Key Words: Nuclear power plants, Seismic design, Accelerograms

Based on the main features of the computer program THGE, the paper reviews the techniques which are available for the construction of an accelerogram whose response spectrum matches a design spectrum. A sample accelerogram is generated as the product of the stationary random sequence by a deterministic shape function. Procedures are described which are available, both in the frequency domain and in the time domain, to improve the agreement between the response spectrum and the target.

VEHICLE SYSTEMS

GROUND VEHICLES
(Also see No. 2806)

84-2656
Design Features of Low-Noise Tire Treads (Konstruktionsmerkmale geräuscharmer Reifenprofile)

T. Reese, D. Denker, G. Muller, and D. Zoglowek
Automobiltech. Z., 86 (6), pp 261-264 (June 1984)
16 figs, 8 refs
(In German)

Key Words: Interaction: tire-pavement, Noise reduction, Noise generation

This paper deals with the influence of car tires' tread pattern design on tire/road noise. With the aid of modern acoustic measuring technology, a large number of tires with geometrically simple tread patterns, as well as standard tires, were tested systematically in respect to noise. All measurements were made with vehicles on the road. From the results of these investigations conclusions were drawn regarding technical measures intended to improve the noise characteristics of tires' tread patterns.

84-2657
Mathematical Modelling to Simulate the Transient Dynamic Longitudinal Force in Draw Bars of a Train-Consist

J.S. Rao, E. Raghavacharyulu, and N. Kumar
Indian Inst. of Tech., Delhi, Hauz Khas, New Delhi -- 110016, India, J. Sound Vib., 94 (3), pp 365-379 (June 8, 1984) 11 figs, 6 tables, 8 refs

Key Words: Railroad trains, Draw-bars, Transient response, Modal analysis

This paper deals with the theory and development of a computer-oriented mathematical model to determine the transient response and coupling (draw-bar) forces of a train-consist subjected to different train handling conditions. The longitudinal motion is assumed to take place independently and the equations of motion for the system are set up in a matrix form. A transfer matrix method is adopted to determine the free vibration characteristics. The response of the system due to the transient forces is obtained by modal analysis with account taken altogether of five modes, including the rigid body mode. The displacement response and the draw-bar forces obtained for a typical train-consist are presented in tables and figures. The computer programs developed can be used to lay down train handling and make up procedures to avoid possible dangerous conditions of draw-bar failures.

84-2658
Curving Simulation of Four Axle Railway Vehicles with Conventional Two Axle Bogies

T. Hirotsu, F. Iwasaki, K. Terada, and M. Ariga
Hitachi Res. Lab., Hitachi, Ltd., Mito, Japan, Bull. JSME, 27 (228), pp 1272-1279 (June 1984) 15 figs, 5 refs

Key Words: Railroad cars, Cornering effects, Interaction: rail-vehicle

A dynamic model is developed for curving of four axle rail vehicles with conventional two axle bogies, and equations of their motion are derived. Digital simulations are made to obtain time history of rail-wheel vertical and lateral forces during curving.

SHIPS

84-2659
A Method for the Prediction of Noise and Velocity Levels in Ship Constructions

A.C. Nilsson
Danish Acoustical Inst., Technical Univ., Bldg. 352,

DK-2800, Lyngby, Denmark, J. Sound Vib., 94 (3), pp 411-429 (June 8, 1984) 11 figs, 23 refs

Key Words: Ships, Noise prediction, Noise reduction

Models describing the propagation of flexural waves in ribbed steel structures typical for ship constructions are presented. Two models are discussed. One is valid in the low frequency range -- in the octave bands with center frequencies from 31.5 Hz to 125 Hz. The other model can be used in the 250 Hz to 8 kHz octave bands. Predicted results are compared to the results of full-scale measurements carried out on a ship.

84-2660
Upper Ball Joint Force Variations Due to Riser Tensioner and Vessel Motions
J.E. Lovell
Ph.D. Thesis, Texas A&M Univ., 119 pp (1983)
DA8408452

Key Words: Ships, Marine risers

An analysis of the variation of forces acting on the upper ball joint of a riser string due to drill ship motion and riser tensioner dynamics has been conducted. The analysis includes the effect of breakaway torque on the tensioner sheaves while assuming vessel and upper ball joint motion to be independent. General equations for the tensioner cable forces and for the forces exerted on the riser upper ball joint by the slip joint-tensioner system are derived and solved. The variation in tensioner cable forces is compared to data generated in field operations.

84-2661
Reflections on Trends in Dynamics – The Navy's Perspective
H.C. Pusey
NKF Engineering Associates, Inc., Vienna, VA, Shock Vib. Bull., No. 54, Pt, 1, pp 59-64 (June 1984) 18 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Ships

Dynamics, that branch of mechanics which deals with forces and their relation to the motion of bodies, is an area that is important to designers of equipment for all types of systems.

In this paper the dynamics is considered from the perspective of the Navy. Some trends in that area are examined and some problems that will require attention in the future are highlighted.

84-2662
Fatigue Considerations in View of Measured Load Spectra
W.G. Dobson, R.F. Brodrick, J.W. Wheaton, J. Giannotti, and K.A. Stambaugh
Teledyne Engineering Services, Waltham, MA, Rept. No. TR-3049-4, SSC-315, 59 pp (1983)
AD-A140 221

Key Words: Ships, Fatigue life, Experimental data

Crack propagation in HY-80 and CS ship steel under typical ship loading time-histories was studied. The loading histories were selected from recorded service stress data which were generated during voyages by the SL-7 containership. Samples of the data were imposed on laboratory specimens as a tape loop signal speeded up by a factor of 25. Analysis of the results indicated that the crack growth during this random loading compared closely with that of constant-amplitude loading if the stress intensity range were expressed as the root-mean-square. It was also determined that significant crack growth retardation effects were present and that omission of low-amplitude high-frequency components of the loading had little effect on the time rate of growth of cracks.

84-2663
Measurements of the Impulse Response and Reverberation Underwater in the Depressurized Towing Tank Marin
A. Debruijn
Technisch Physische Dienst TNO-TH, Delft, The Netherlands, Rept. No. TPD-208.730/1, TDCK-78124, 27 pp (Dec 21, 1982)
N84-22374
(In Dutch)

Key Words: Underwater structures, Towed systems, Impulse response

The underwater impulse response of a depressurized towing tank was determined. An electrodynamic underwater sound source generated a chirp consisting of a relatively long sinusoidal pressure signal with frequency modulation. By

signal processing, the chirp was compressed to a short idealized pulse. The reflectograms obtained with the chirp are also converted to true impulse response data. For a number of positions in the tank, typical for the usual hydrophones, the impulse responses are calculated with the aid of a sound source at the propeller source line. From the echograms it can be seen that the bottom and side wall reflections are not significant in comparison with the direct signal. The impulse response data are used to calculate the reverberation curves by adopting Schroeder's concept of the integrated impulse response.

jet. Because of the temperature and flow discontinuity between the jet and the surrounding air, the parallel jet acts as a partial barrier between the noise source and the receiver. An analytical model of jet shielding has been developed consisting of the sound field emitted from a stationary, discrete frequency point source, which impinges on a cylinder of locally parallel flow. The model is analyzed to identify the zones in which the various shielding mechanisms dominate. The effects of such parameters as jet temperature and flow speed are investigated. The analytical model is compared to experimental results for the shielding of a point noise source adjacent to a subsonic, isothermal air jet.

AIRCRAFT

(Also see Nos. 2634, 2792)

84-2664

Modified Shielding Jet Modal for Twin-Jet Shielding Analysis

C.H. Gerhold and J. Gilbride

Texas A&M Univ., College Station, TX 77843, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 421-426 (July 1984) 8 figs, 15 refs

Key Words: Aircraft noise, Noise reduction, Shielding

An analytical model to estimate the shielding of noise emitted from a point noise source has been developed assuming the shielding jet to be a cylinder of constant radius with uniform flow across the cross section. Comparison to experiment indicated that the model overestimates diffraction of sound around the jet in the far downstream region. The shielding jet model is modified to include widening downstream of the nozzle exit. This not only represents a more realistic model of the jet, but is also expected to improve the shielding estimate downstream.

84-2665

Analysis of the Effect of Heated Jet Flow on the Far Field Radiation from a Noise Source

C.H. Gerhold

Texas A&M Univ., College Station, TX 77843, J. Vib., Acoust., Stress, Res. Des., Trans. ASME, 106 (3), pp 427-433 (July 1984) 8 figs, 12 refs

Key Words: Aircraft noise, Noise reduction, Shielding, Noise shielding

One factor which influences the radiation of jet noise is the interaction with the heated moving flow of a parallel twin

84-2666

General Equations of Motion for an Elastic Wing and Method of Solution

V.J.E. Stark

Saab Scania AB, Linkoping, Sweden. AIAA J., 22 (8), pp 1146-1153 (Aug 1984) 5 figs, 4 tables, 20 refs

Key Words: Aircraft wings, Equations of motion, Time domain method

Equations in the time domain for arbitrary motion of a finite elastic wing in linearized flow are derived by means of more general indicial aerodynamic coefficients than those previously defined. Solution by the Laplace transformation shows that the normal response contains a line integral that depends on the discontinuity of the aerodynamic transfer functions across the negative real axis. For these functions, approximations of the Garrick type are utilized in a root-locus method in which no augmented states are needed.

84-2667

Noise Transmission Characteristics of Advanced Composite Structural Materials

L.A. Roussos, C.A. Powell, F.W. Grosveld, and L.R. Koval

NASA Langley Res. Ctr., Hampton, VA, J. Aircraft, 21 (7), pp 528-535 (July 1984) 8 figs, 6 tables, 10 refs

Key Words: Aircraft, Composite materials, Noise transmission

An experimental and theoretical research program has begun to develop an understanding of the noise transmission characteristics of composite materials. Such an understanding will ensure that the weight advantage of composites in aircraft fuselage design is not compromised by high noise transmis-

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sion or heavy acoustic treatments. Noise transmission tests have been conducted on large unstiffened panels representative of the outer skin or inner trim panels of aircraft fuselages. An analytical model based on infinite panel theory has been developed which allows for exact modeling of the anisotropic properties of the panels.

84-2668

Parameter Identification Applied to the Oscillatory Motion of an Airplane Near Stall

J.G. Batterson and V. Klein

Key Words: Aircraft vibration, Flight test data, Parameter identification technique, Regression analysis

An application is presented of a stepwise regression incorporating polynomial splines to oscillatory flight data from a light research airplane operating at near-stall angles of attack. It is shown that data from several experiments can be combined into a large data set for analysis and that hysteresis phenomena can be observed in this large data set.

84-2669

Reliability Analysis and Cost Optimization of Fatigue-Critical Components under Scheduled Inspection Maintenance in Service

Shiung Chen

Key Words: Aircraft, Fatigue life

Conventional deterministic design of aircraft fatigue-critical components has resulted in conservation underestimation and poor utilizations of inherent fatigue life. The effect of scheduled inspection maintenance in service normally are not accounted for at the design stage. In this dissertation probabilistic methodologies are developed for reliability analyses and cost optimization of fatigue-critical components under scheduled inspection maintenance in service. Emphasis is placed on the development of retirement-for-cause analysis methodologies for gas turbine engine components, based on fracture mechanics approach.

84-2670

Transonic Pressure Distributions on a Rectangular Supercritical Wing Oscillating in Pitch

R.H. Ricketts, M.C. Sandford, D.A. Seidel, and J.J. Watson

Key Words: Aircraft wings, Oscillation

Steady and unsteady aerodynamic data were measured on a rectangular wing with a 12% thick supercritical airfoil mounted in the NASA Langley Transonic Dynamics Tunnel. The wing was oscillated in pitch to generate the unsteady aerodynamic data. The purpose of the wind-tunnel test was to measure data for use in the development and assessment of transonic analytical codes. The effects on the wing pressure distributions of Mach number, mean angle of attack, and oscillation frequency and amplitude were measured.

84-2671

Divergence/Flutter Suppression System for a Forward Swept-Wing Configuration with Wing-Mounted Stores

M. Rimer, R. Chipman, and R. Mercadante

Key Words: Aircraft wings, Wing stores, Flutter, Active flutter control

The conceptual design of an active control system has been developed for a forward swept-wing configuration with stores to prevent the destiffening of the primary wing-bending mode with increasing airspeed, thereby suppressing the inherent aeroelastic instability (divergence/body-freedom-flutter). The architecture includes wing-mounted and fuselage-mounted accelerometers to detect relative wing motion and an outboard wing flaperon to control this motion. By virtually eliminating the instability, the design enables the aircraft to carry significant wing-mounted stores while retaining the clean-wing flight envelope.

84-2672

Nonlinear Finite Element Method in Crashworthiness Analysis of Aircraft Seats

A.O. Bolukbasi and D.H. Laananen

A three-dimensional mathematical model of an aircraft seat, occupant, and restraint system has been developed for use in the analysis of light aircraft crashworthiness. Because of the significant role played by the seat in overall system crashworthiness, a detailed finite element model of the seat structure is included. The seat model can accommodate large displacements, nonlinear material behavior, and local buckling.

MISSILES AND SPACECRAFT
(Also see No. 2830)

84-2673
DNA ICBM Technical R&D Program
M.I. Kovel
Defense Nuclear Agency, Washington, DC, Shock Vib. Bull., No. 54, Pt. 1, pp 23-41 (June 1984) 25 figs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

After a brief introduction of the Defense Nuclear Agency, the DNA program on basing of primarily small missiles, namely hard silos and hard mobile launchers, is described.

84-2674
Air Force Space Technology Center Space Technology -- Emphasis 84
F.J. Redd
Air Force Space Technology Center, Kirtland AFB, NM, Shock Vib. Bull., No. 54, Pt. 1, pp 55-57 (June 1984) (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

The mission of AFSTC, to centralize the planning and execution of space technology in support of future Air Force space systems requirements, is described.

BIOLOGICAL SYSTEMS

HUMAN

84-2675
Lubrication of Elastic-Isoviscous Line Contacts Subject to Cyclic Time-Varying Loads and Entrainment Velocities
J.B. Medley and D. Dowson
Univ. of Waterloo, Waterloo, Canada, ASLE, Trans., 27 (3), pp 243-251 (July 1984) 7 figs, 28 refs

An analytical approach was developed for the difficult problem of predicting the dynamic variation in fluid-film thickness of elastic-isoviscous line contacts under isothermal conditions. A numerical solution procedure was constructed and applied to the experiments of Hirano and Murakami who were investigating the lubrication of O-ring seals. Reasonable agreement was obtained. The present approach was extended to the lubrication of compliant layered surfaces as part of a study of human ankle joint lubrication.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS
(Also see Nos. 2710, 2743, 2806)

84-2676
An Active Sound Absorber with Porous Plate
D. Guicking and E. Lorenz
Drittes Physikalisches Institut, Univ. of Göttingen, Göttingen, Fed. Rep. Germany, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 389-392 (July 1984) 6 figs, 3 refs

An active equivalent of a resonance absorber with a porous plate is described. The porous layer is backed by a loud-

speaker driven such that zero sound pressure is maintained in the air gap between foil and speaker. The simultaneous control of magnitude and phase has been achieved in analog technique by a combination of open-loop and closed-loop control, utilizing single sideband modulation of the compensation signal with a weak infrasonic auxiliary signal.

84-2677
Active Impedance Control for One-Dimensional Sound
D. Guicking and K. Karcher
Drittes Physikalisches Institut, Univ. of Göttingen, Göttingen, Fed. Rep. Germany,

Generalizing the concept of active sound absorption, a system for active impedance control has been developed, so far for plane waves at normal incidence. The active reflector is a loudspeaker driven by the incident sound wave. Its feeding signal is derived from a wave separator with two microphones splitting up the standing wave field into incident and reflected wave. This system permits easy control of the reflection coefficient and eliminates feedback instability.

84-2678
Antivibration Mountings. 1970 - April, 1984 (Citations from the Engineering Index Data Base)

This bibliography contains 94 citations concerning mechanical and fluid antivibration mountings. Citations are included which offer vibration damping methods for buildings as well as machinery. New materials and new methods are discussed in the automotive, machinery, nuclear and construction industries. Various methods of measuring vibration are also presented.

84-2679
Finite Amplitude Vibrations of a Body Supported by Simple Shear Springs
M.F. Beatty
Univ. of Kentucky, Lexington, KY 40506,

The exact solution of the problem of the undamped, finite amplitude oscillations of a mass supported symmetrically by simple shear mounts, and perhaps also by a smooth plane surface or by roller bearings, is derived for the class of isotropic, hyperelastic materials for which the strain energy is a quadratic function of the first and second principal invariants and an arbitrary function of the third. The Mooney-Rivlin and Hadamard material models are special members for which the finite motion of the load is simple harmonic and the free fall dynamic deflection always is twice the static deflection. Otherwise, the solution is described by an elliptic integral which may be inverted to obtain the motion in terms of Jacobi elliptic functions.

84-2680
Generalized Rigid-Body Dynamics System Simulation and the Application to the Behavior of Suspended Agricultural Tractors
P.W. Claar, II

Low frequency terrain-induced tractor vibration levels exceed proposed International Standards Organization fatigue-decreased proficiency limits. A suspension system is needed to protect the operator and attenuate the vibration inputs to the chassis and the operator platform for high speed farming systems. Computer simulation modeling of the suspension system provides information for the design and about its performance. The design considerations for off-road vehicle operator ride comfort, the means to improve ride comfort, and computer simulation techniques to evaluate ride comfort are discussed. A matrix-computer procedure for the vibrational analysis of articulated planar and spatial mechanisms is presented and the development of a chassis suspension system is discussed.

84-2681
Eccentricities of Resultant Loads from Compression Coil Springs (Exzentrische Lagen der Reaktionskräfte bei Schraubendruckfedern)
G.D. Go

Kapellenstrasse 42, 5860 Iserlohn 5, Germany, Auto-
mobiltech. Z., 86 (5), pp 227-232 (May 1984) 8 figs
(In German)

Key Words: Suspension systems (vehicles), Shock absorbers,
Wear

The factors influencing the locations of eccentric centers,
the seating loads and engineering applications for the future
to cut development costs and time are presented. The seating
loads can be used right during the development of a suspen-
sion system to gain knowledge concerning its service life
and response when in operation. The finite-element approach
used was based on the theory of forces of the first order for
straight beams.

TIRES AND WHEELS
(See No. 2810)

BLADES
(Also see No. 2709)

84-2682
Flapping-Torsional Response of Helicopter Rotor
Blades to Turbulence Excitation
Jon-Shen Fuh
Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign,
166 pp (1983)
DA8409925

Key Words: Blades, Propeller blades, Helicopters, Torsional
response, Turbulence, Fluid-induced excitation

Dynamics of a helicopter rotor system in atmospheric turbu-
lence is investigated theoretically. Modeling turbulence com-
ponents as stationary random processes, differential equa-
tions governing the coupled flapping-torsional motion of a
rotor blade are derived. The blade is treated as being rigid
and centrally hinged for the flapping motion, and as being
elastic with a linear deformation mode for the torsional
motion. Classical steady theory is used to formulate the
aerodynamic forces due to blade flapping. For those due to
blade pitching, a quasi-steady theory is used. The governing
equations so obtained contain random turbulence terms in
the coefficients and the inhomogeneous parts. In the second
stage of investigation, the analytical procedure is extended to
multibladed systems.

BEARINGS
(Also see No. 2812)

84-2683
Investigation of Friction and Wear of Dynamically
Loaded Hydrodynamic Bearings with Abrasive Con-
taminants
A. Ronen and S. Malkin
Technion-Israel Inst. of Tech., Haifa 32000, Israel,
J. Lubric. Tech., Trans. ASME, 105 (4), pp 559-568
(Oct 1983) 16 figs, 10 refs

Key Words: Bearings, Wear

A test system is described for investigating friction and wear
of hydrodynamic bearings under cyclical dynamic loading
conditions with contaminant abrasive particles in the oil
supply. Dynamic loading on the test bearing is synchronized
with the shaft rotation, so that the oil film thickness history
can be determined from the measured shaft orbit for any
point on the shaft and liner periphery. Either clean or con-
taminated oil can be supplied to the test bearing from two
separate oil supply systems. Experimental results obtained
for six shaft/liner bearing material combinations were similar
to those previously obtained for static loading.

84-2684
Energy Loss Due to Misalignment of Journal Bearings
Z.S. Safar
Cairo Univ., Cairo, Egypt, Trib. Intl., 17 (2), pp 107-
109 (Apr 1984) 5 figs, 4 refs

Key Words: Bearings, Journal bearings, Alignment

An analysis of a journal bearing describing a maximum allow-
able value of misalignment at a length to diameter ratio of
unity is presented. The journal misalignment is allowed to
vary in direction up to a direction normal to the axial plane
containing the load vector. The results demonstrate that
journal misalignment influences bearing behavior.

84-2685
Stability Analysis of Externally-Pressurized Gas-
Lubricated Porous Bearings with Journal Rotation.
Part 1. Cylindrical Whirl
D.K. Pal and B.C. Majumdar

Indian Inst. of Tech., Kharagpur, India, Trib. Intl.,
17 (2), pp 83-91 (Apr 1984) 13 figs, 1 table, 7 refs

Key Words: Bearings, Journal bearings, Gas bearings, Whirling

Whirl stability (cylindrical) of externally-pressurized gas-lubricated porous journal bearings, considering one-dimensional flow through the porous matrix, is analyzed by a first-order perturbation method. The effect of supply pressure, feeding parameter, porosity parameter and length-to-diameter ratio on the stability is also investigated.

84-2686
Stability Analysis of Externally-Pressurized Gas-Lubricated Porous Bearings with Journal Rotation. Part 2. Conical Whirl

D.K. Pal and B.C. Majumdar
Indian Inst. of Tech., Kharagpur, India, Trib. Intl.,
17 (2), pp 92-98 (Apr 1984) 10 figs, 9 refs

Key Words: Bearings, Journal bearings, Gas bearings, Whirling

The stability analysis of externally pressurized gas journal bearings under conical mode of vibration is obtained using a first-order perturbation method. The effect of journal speed, feeding parameter, supply pressure, porosity parameter and length-to-diameter ratio on the conical whirl and whirl ratio is investigated.

84-2687
Bifurcation Theory Applied to Oil Whirl in Plain Cylindrical Journal Bearings

C.J. Myers
Dept. of Applied Mathematical Studies, Univ. of Leeds, Leeds LS2 9JT, UK, J. Appl. Mech., Trans. ASME, 51 (2), pp 244-249 (June 1984) 6 figs, 1 table, 17 refs

Key Words: Bearings, Self-excited vibrations, Oil whirl phenomena

An analysis of the self-excited oscillations of a rotor supported in fluid film journal bearings is presented. It is shown that Hopf bifurcation theory may be used to investigate small-amplitude periodic solutions of the nonlinear equations of motion for rotor speeds close to the speed at which the steady-state equilibrium position becomes unstable. A numerical investigation supports the findings of the analytic work.

84-2688
Literature Review of Tilting Pad and Turbulent Hydrostatic Journal Bearings for Nuclear Main Coolant Pumps

R.D. Flack and P.E. Allaire
Univ. of Virginia, Charlottesville, VA 22901, Shock Vib. Dig., 16 (7), pp 3-12 (July 1984) 4 figs, 58 refs

Key Words: Bearings, Tilt pad bearings, Hydrostatic bearings, Cooling systems, Pumps, Reviews

Research regarding tilting-pad and turbulent hydrostatic journal bearings is reviewed. Included are both theoretical and experimental work. Both static and dynamic characteristics are considered. The purpose of this paper is to enable a practicing engineer to apply presently available methods so that he can reliably predict load capacities and dynamic coefficients for the bearings.

GEARS
(Also see No. 2694)

84-2689
Estimating Dynamic Loads on Gear Teeth

M.F. Spotts
Northwestern Univ., Evanston, IL, Mach. Des., 56 (16), pp 84-88 (July 12, 1984) 4 figs

Key Words: Gear teeth, Error analysis

One of the most widely accepted procedures for estimating dynamic loads involves the use of a mass/spring model that simulates the effects of manufacturing errors. Errors in tooth profile and tooth spacing are major causes of dynamic loads. Factors that influence dynamic forces include operating speed, spring constant of meshing gear teeth, and mass of the rotating gears. All of these factors are considered in the method presented in this article for estimating dynamic tooth loads and spur gears.

84-2690
Root Stresses and Bending Fatigue Breakage of Planet Gear

S Oda, K. Miyachika, and A. Takeda
Tottori Univ., 4 101 Minami, Koyama-cho, Tottori, Japan, Bull. JSME, 27 (227), pp 995-1001 (May 1984) 18 figs, 6 refs

36

Key Words: Gears, Fatigue tests, Finite element technique

A root stress analysis by means of the two-dimensional finite element method and a bending fatigue test for planet and idle gears were carried out. The effects of rim thickness and internal pressure due to a press-fitted bush on the root stresses and the position of the fatigue crack initiation were investigated.

84-2691
Laws of Motion for Non-Vibrating Cranks
H. Dresig and J. Rossler
Technische Hochschule Karl-Marx-Stadt, Sektion Maschinen-Bauelemente, Maschinenbautechnik, 33 (5), pp 201-204 (1984) 5 figs, 10 refs
(In German)

Key Words: Cranks, Design techniques, Computer programs, Vibration control

The maximum operating speeds of many cam gears are restricted by forced vibrations. The speeds can be increased to almost resonant speeds of the highest harmonics by means of a new cam profile design. A computer program, KUSY, was developed which synthesizes such cam profiles. Tests showed that the new profile enabled to raise the maximum operating speeds of various machinery. A test with a warped knitting loom is described.

COUPLINGS

84-2692
Subharmonic Resonances in Prime Mover Systems Incorporating Diesel Engines (Subharmonische Resonanzen in dieselmotorischen Antriebsanlagen)
V. Zoui
Frydlantska 1316/11, 182 00 Praha 8/CSSR, MTZ Motortech. Z., 45 (6), pp 253-255 (June 1984) 4 figs, 5 refs
(In German)

Key Words: Couplings, Flexible couplings, Diesel engines, Subharmonic oscillations

Wherever a flexible shaft coupling with a nonlinear characteristic is connected to a diesel engine to drive machinery, there is a risk that subharmonic resonances will occur in view of the fact that they represent a phenomenon typical of

nonlinear oscillations. This article describes a method of calculating the amplitude of subharmonic nonlinear oscillations; it can be also applied using simple computer technology. The conditions at which subharmonic oscillations can originate are specified.

84-2693
Selection of Flexible Couplings for Marine Propulsion Engines with Power Take-Off (Auswahl elastischer Kupplungen fur Schiffsdieselmotoren mit Leistungsverzweigung)
F. Martinek
Eichenweg 35, A-5302 Henndorf, Germany, MTZ Motortech. Z., 45 (6), pp 251-252 (June 1984) 1 fig, 1 table, 3 refs
(In German)

Key Words: Couplings, Flexible couplings, Marine engines, Torsional vibrations

The author describes the process of making a preliminary selection with or without computer assistance of the flexible couplings to be used in a typical marine propulsion system incorporating a medium-speed, 4-stroke diesel engine to drive a propeller through a reduction gear and an auxiliary alernator through a step-up gear. After such an initial coupling selection on the basis of torque, simple formulae can be used to predict torsional vibrations.

LINKAGES

84-2694
Application of the Analysis of Bi-Parametric Dissipative Oscillations to the Crank with Connecting Rod Assembly and to the Eccentric Gear
I. Misicu
Polytechnical Inst., Bucharest, Romania, Rev. Roumaine Sci. Tech., Mecanique Appl., 29 (2), pp 187-192 (Mar/Apr 1984) 6 figs, 2 refs

Key Words: Cranks, Connecting rods, Gears

On the basis of a previously developed analysis of bi-parametric dissipative oscillations, a procedure is developed for determining the critical stability parameters for two types of usual mechanisms -- a crank with a connecting rod assembly and an eccentric gear.

37

SEALS

STRUCTURAL COMPONENTS

84-2695

A Study on the Dynamic Characteristics of Pump Seal (1st Report, In Case of Annular Seal with Eccentricity)

Bo Suk Yang, T. Iwatsubo, and R. Kawai
Graduate School of Science and Tech., Kobe Univ., Rokkodai Nada-Ku, Kobe, Japan, Bull. JSME, 27 (227), pp 1047-1053 (May 1984) 5 figs, 11 refs

Key Words: Seals, Pumps

The dynamic characteristics of the annular pressure seal employed in pumps have been theoretically deduced with consideration for the effect of eccentricity of rotor. Turbulent flow is assumed in both circumferential and axial directions, and effect of inertia of the fluid is considered. An equation for the pressure increment due to journal translation is derived in terms of the effective viscosities, based on the rotational and axial flow Reynolds numbers.

84-2696

Pumping Action of Aligned Smooth Face Seals Due to Axial Vibrations -- Theory

M. Kaneta, Y. Jonnouchi, and F. Fukahori
Kyushu Inst. of Tech., Sensui-cho, Tobata, Kita-Kyushu, 804, Japan, J. Trib., Trans. ASME, 106 (3), pp 344-351 (July 1984) 7 figs, 26 refs

Key Words: Seals, Periodic excitation

This is an analytical study of the mechanism of pumping action produced in two axially symmetrical disks. The disks have a continuous parallel film thickness between them, and one of them has a recess at the center and is subjected to a normal sinusoidal oscillation. It is found out that whether the pumping action is inward or outward depends upon a shift of phase between a variation of flow resistance due to a periodic fluctuation of the film thickness between seal faces and a variation of pressure in the recess.

STRINGS AND ROPES

84-2697

Nonlinear Generation of Missing Modes on a Vibrating String

K.A. Legge and N.H. Fletcher
Univ. of New England, Armidale 2351, Australia, J. Acoust. Soc. Amer., 76 (1), pp 5-12 (July 1984) 7 figs, 1 table, 9 refs

Key Words: Strings, Vibration analysis

The nonlinear transfer of energy among modes of different frequencies on a vibrating string is investigated both theoretically and experimentally. The nonlinearity is associated with the well-known variation of string tension caused by the vibration modes, but it is essential that at least one of the end supports has finite mechanical admittance if there is to be any mode coupling. If the nonrigid bridge support has zero admittance in a direction parallel to the string, the coupling is of third order in the mode amplitudes. For a more realistic model in which the string changes direction as it passes over a bridge of finite admittance there are additional coupling terms of second order.

CABLES

84-2698

Dynamic Phenomena in Ropeways After a Haul Rope Rupture

B. Portier
Service de Mecanique, Laboratoire Central des Ponts et Chaussees, 58 Boulevard Lefebvre, 75732 Paris Cedex 15, France, Earthquake Engrg. Struc. Dynam., 12 (4), pp 433-449 (July/Aug 1984) 8 figs, 2 tables, 16 refs

Key Words: Cable cars, Cables

An accurate prediction of the dynamical behavior of reversible aerial ropeways is presented. A mechanical and numerical model is developed in order to check the safety of any such ropeway after a haul rope rupture. The model uses very

simple first-order finite elements, accounting for nonlinear effects caused by large displacements. The numerical integration is very efficient, and suits the capabilities of small microcomputers; it does not require matrix inversions nor stiffness matrix evaluations.

84-2699
Dynamic Relaxation Analysis of the Non-Linear Static Response of Pretensioned Cable Roofs
W.J. Lewis, M.S. Jones, and K.R. Rushton
The Polytechnic, Wolverhampton, England, Computer Struc., 18 (6), pp 989-997 (1984) 9 figs, 5 tables, 15 refs

Key Words: Cables, Roofs, Dynamic relaxation

A summary of various existing methods of cable roof analysis is followed by a detailed description of a dynamic relaxation technique that can be applied for the solution of such structures. Theoretical analysis of static response of pretensioned cable networks is presented using a nonlinear energy approach. Solutions are obtained by dynamic relaxation, a numerical finite difference technique. Detailed results are presented for a pretensioned cable truss.

BARS AND RODS

84-2700
Investigation of Stress Wave Propagation through Intersecting Bars
K.R.Y. Simha and W.L. Fourney
Univ. of Maryland College Park, MD 20742, J. Appl. Mech., Trans. ASME, 51 (2), pp 345-353 (June 1984) 19 figs, 21 refs

Key Words: Bars, Stress waves, Wave propagation

A general formulation is presented for the analysis of stress wave propagation through the junction of rectangular bars. The analysis is applied to the case of two bars meeting at right angles and is used to theoretically predict the passage of longitudinal waves through the junction. An experimental investigation of the phenomenon, using dynamic photoelasticity is conducted with a high-speed multiple spark gap camera of the Cranz-Schardin type. Three different geometries are tested to represent the most common types of junctions encountered in practice.

84-2701
Propagation of Elastic Waves in a Finite Length Bar with a Variable Cross Section
M. Daimaruya, M. Naitoh, and K. Hamada
Muroran Inst. of Tech., 27-1 Mizumoto-cho, Muroran, Japan. Bull. JSME, 27 (227), pp 872-878 (May 1984) 9 figs 12 refs

Key Words: Bars, Variable cross section, Elastic waves, Wave propagation, Impact excitation

The propagation of elastic waves in a finite length bar with a variable cross section subjected to an arbitrary longitudinal impact loading is investigated. The solution is obtained by the application of the Laplace transform. The results of this analysis can be applied only to a thin bar with small changes of area and to waves which are long compared to the lateral dimensions of the bar. Numerical calculations are carried out for the case of truncated cones, and strain wave histories at various stations along the bar are shown for two kinds of impact loading.

84-2702
Analysis of Vibration of a Group of Rods in a Fluid by Approximation of Flow-path Network (Report I. Simplified Vibration Model of a Group of Rods)
H. Tomita and Y. Sasaki
Toshiba Res. and Dev. Ctr., Toshiba Corp., 1, Komukai, Toshiba-cho, Saiwaiku, Kawasaki 210, Japan, Bull. JSME, 27 (227), pp 956-964 (May 1984) 19 figs, 6 refs

Key Words: Rods, Submerged structures, Multibeam systems, Fluid-induced excitation, Nuclear fuel elements, Seismic design

A practical approximate method of analysis of a group of rods in a fluid is presented. A simplified model of the rod/fluid system is presented and its applicability to practice is verified through theoretical and experimental analysis.

84-2703
Analysis of Vibration of a Group of Rods in a Fluid by Approximation of Flow-Path Network (Report II. Continuous Body Model of a Group of Rods)
H. Tomita
Toshiba Res. and Dev. Ctr., Toshiba Corp., 1, Komukai, Toshiba-cho, Saiwaiku, Kawasaki 210, Japan, Bull. JSME, 27 (227), pp 965-973 (May 1984) 13 figs, 3 refs

In this paper a group of rods is treated as if it were a continuous body as a whole. A more generalized and widely applicable model of the rod/fluid system is presented, and its validity for practical use is shown through experiment.

to three-dimensional harmonic loads, is presented. Each differential element of the beam has six degrees of freedom; i.e., three translations and three rotations. This problem, in the most general case of response, is associated with a partial linear differential system composed of four coupled 3×1 vectorial equations. The influences of transverse shear deformation and rotatory inertia are also included in the analysis.

BEAMS

84-2704

Stress-Displacement Analysis in Random Coupled Vibration of Bundles of Elastic Rods

D. Dinca
National Inst. for Scientific and Technical Creation, Bdul Pacii 220, 79622, Bucharest, Romania, Rev. Roumaine Sci. Tech., Mecanique Appl., 29 (2), pp 147-158 (Mar/Apr 1984) 2 figs, 2 tables, 8 refs

A stress-displacement analysis is developed for a bundle of parallel, cylindrical, elastic rods, immersed in an ideal incompressible fluid, using three beam models: the Bernoulli-Euler model, the Rayleigh model which includes the rotatory inertia effect, and the Timoshenko one which includes both the rotatory inertia effect and the shear forces effect. Numerical results are obtained for two types of random loads.

84-2705

Three-Dimensional Harmonic Vibrations of a Circular Beam

D.E. Panayotounakos and P.S. Theocaris
The National Technical Univ. of Athens, 5, K. Zographou St., Zogarphou, Athens 624, Greece, J. Appl. Mech., Trans. ASME, 51 (2), pp 375-382 (June 1984) 1 fig, 2 tables, 11 refs

An analytical treatment for the determination of the natural frequencies of a circular uniform beam, subjected

84-2706

Dynamic Stability of Thin Walled Beams under Traveling Horizontal Follower Load Systems

T. Aida
Yamaguchi Univ., Ube, Japan, J. Sound Vib., 94 (3), pp 431-444 (June 8, 1984) 10 figs, 5 refs

The dynamic elastic instability of a thin walled beam under traveling horizontal transverse follower load systems caused by nosing and yawing motions of vehicles; e.g., magnetically levitated vehicles, is considered. It is shown that the perturbation equation of motion of this beam system becomes Hill's equation and a parametrically excited unstable coupled vibration occurs. Furthermore, the boundary frequency equations of the simple parametric resonance are obtained by Bolotin's method, and the stability maps of a simply supported beam are shown, as influenced by load mass and damping.

84-2707

Improved Finite-Difference Vibration Analysis of Pretwisted, Tapered Beams

K.B. Subrahmanyam and K.R.V. Kaza
NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. E-1923, NASA-TM-83549, 13 pp (1984)
N84-16588

An improved finite difference procedure based upon second order central differences is developed. Several difficulties encountered in earlier works with fictitious stations that arise in using second order central differences, are eliminated by developing certain recursive relations. The need for forward or backward differences at the beam boundaries or other similar procedures is eliminated in the present theory. By using this improved theory, the vibration characteristics of pretwisted and tapered blades are calcu-

lated. Results of the second order theory are compared with published theoretical and experimental results and are found to be in good agreement.

84-2708

Bending of Beams Subjected to Transverse Impacts

R.L. Woodward

Materials Res. Labs., Ascot Vale, Australia, Rept. No. MRL-R-886, 24 pp (Apr 1983)
AD-A137 840

Key Words: Beams, Impact excitation, Computer programs

Transverse projectile impacts on the ends of free-free beams of circular cross section produced evidence of hinges in the beams and strain distributions which could be used for comparisons with a rigid-plastic approach to the dynamic response of structures and for comparisons with a finite element computer code solution. The rigid-plastic approach describes the mechanism of bending and hinge development and motion correctly but the simplifications inherent in the model prevent it from accurately predicting the detail. The computer code EPIC-2 gives extremely good simulations of the problem.

84-2709

Blade Excitation Due to Gyroscopic Forces

F. Sisto, A.T. Chang, and M. Sutcu

Dept. of Mech. Engrg., Stevens Inst. of Tech., Rotordynamic Problems in Power Plants, Intl. Conf., Intl. Fed. for Theory of Machines and Mechanisms, Tech. Comm. for Rotor Dynamics, Sept 28 - Oct 1, 1982, Rome, Italy, pp 279-284, 5 figs, 5 refs

Key Words: Beams, Cantilever beams, Blades, Rotor blades (turbomachinery), Mountings, Whirling, Seismic excitation

A turboblade mounted on a spinning and precessing rotor is modeled as a uniform cantilever beam (with bending in one plane) with the objective of efficiently conducting parametric studies. The effect that is considered is the response due to a harmonic variation with time of the precessional rate such as is attributable to whirling, seismic ground motion, or other periodic disturbances acting upon mounts of the axial turbomachine. The results are presented in the form of (self-excited) instability criteria. The effects of viscous damping and negative damping (rate of growth) of the unstable vibration are also studied for the case of a constant (nonharmonic) precession rate.

84-2710

Vibrations of Beams with an Absorber Consisting of a Viscoelastic Solid and a Beam

H. Yamaguchi and H. Saito

Tohoku Univ., Sendai, Japan, Earthquake Engrg. Struc. Dynam., 12 (4), pp 467-479 (July/Aug 1984) 10 figs, 7 refs

Key Words: Beams, Dynamic vibration absorption (equipment)

This paper considers the response of a beam with a dynamic vibration absorber, which consists of a viscoelastic solid and a double-cantilever viscoelastic beam, attached to the center of the main beam. The ends of the main beam are built in and excited sinusoidally by the base motion. The transfer matrix method is used in the analysis. The displacement transmissibility; i.e., the ratio of the displacement at the center of the main beam to that of the base is investigated in the numerical example.

84-2711

Shear Strength of Reinforced Concrete Beam-Column Joints under Low Reversed Cyclic Loading

Research Group on Frame Joints, J. Bldg. Structure, 4 (6), pp 1-17 (1983)
CSTA 624-83.132

Key Words: Joints (junctions), Beam-columns, Reinforced concrete, Cyclic loading, Seismic design

Thirty specimens of beam-column joints in reinforced concrete frames under low reversed cyclic loading cases are tested. The investigation includes deformability, shear strength, failure mechanism in joint core region and their effecting factors, such as the confinement of concrete by orthogonally connected beams, axial stress ratio, shear stress ratio, stirrup ratio and slip of beam bars. A seismic design method for calculating shear resisting values and recommendations of beam-column joint core are presented.

PANELS

84-2712

Influence of Geometric Imperfections and In-Plane Constraints on Nonlinear Vibrations of Simply Supported Cylindrical Panels

D. Hui

Ohio State Univ., Columbus, OH 43210, J. Appl. Mech., Trans. ASME, 51 (2), pp 383-390 (June 1984) 6 figs, 22 refs

Key Words: Panels, Cylinders, Vibration analysis, Large amplitudes

This paper deals with the effects of initial geometric imperfections on large-amplitude vibrations of cylindrical panels simply supported along all four edges. In-plane movable and in-plane immovable boundary conditions are considered for each pair of parallel edges. Depending on whether the number of axial and circumferential half waves are odd or even, the presence of geometric imperfections (taken to be of the same shape as the vibration mode) of the order of the shell thickness may significantly raise or lower the linear vibration frequencies.

84-2713
Free Vibrations of Oval Cylindrical Panels
V.K. Koumousis and A.E. Armenakas
Consulting Engr., Athens, Greece, ASCE J. Engrg. Mech., 110 (7), pp 1107-1123 (July 1984) 7 figs, 3 tables, 10 refs

Key Words: Panels, Cylindrical plates, Natural frequencies, Mode shapes, Geometric effects, Flugges shell theory, Donnel theory

The dynamic characteristics of oval cylindrical panels, with simply supported curved edges and various boundary conditions along the straight edges, are established on the basis of the Flugge or Donnell type theories. Numerical results are presented and the effect of the ovality as well as other geometric parameters of the panels are investigated.

84-2714
Vibrations of Axially Loaded Stiffened Cylindrical Panels with Elastic Restraints
J. Singer, O. Rand, and A. Rosen
Dept. of Aeronautical Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Sound Vib., 93 (3), pp 397-408 (Apr 8, 1984) 3 figs, 2 tables, 33 refs

Key Words: Panels, Cylinders, Stiffened structures, Vibration analysis, Computer programs

A method has been developed for analysis of the vibration and buckling of preloaded stiffened cylindrical panels with

different boundary conditions along the straight edges, including elastic restraints. In the analysis linear, "smeared" stiffener, Flügge type theory is used. A computer program VIBUPAL has been developed.

84-2715
Free Vibration of Noncircular Cylindrical Panels with Simply Supported Curved Edges
V.K. Koumousis and A.E. Armenakas
National Technical Univ., Athens, Greece, ASCE J. Engrg. Mech., 110 (5), pp 810-827 (May 1984) 3 figs, 13 refs ·

Key Words: Panels, Cylindrical plates, Donnell theory, Flugges shell theory

A method is presented, employing Flugge and Donnell type theories, for obtaining the dynamic characteristics of cylindrical panels of noncircular cross section, having simply supported curved edges and any boundary conditions along their straight edges. Special formulas are derived for symmetric and doubly-symmetric cylindrical panels.

PLATES
(Also see Nos. 2734, 2763, 2764)

84-2716
Criteria for Placing the Points of Measurement to Obtain the Vibrating Energy of Plates (Critères de maillage pour la mesure d'énergie vibratoire des plaques)
P. Millot, J.L. Guyader, C. Boisson, and C. Lesueur
Laboratoire des Sciences de l'Habitat de l'Ecole Nationale des Travaux Publics de l'Etat, 69120 Vaulx en Velin, France, Acustica, 55 (2), pp 101-112 (May 1984) 16 figs, 13 refs
(In French)

Key Words: Plates, Vibration measurement, Measurement techniques

The aim of this paper is to help to determine criteria for placing the points of measurement on a plate excited by a wide-band random noise force, in order to obtain its vibrating energy. The main parameters which affect the error of method associated with a plate are the number of modes within the bandwidth of excitation, the type of distribution, and the number of points. The results de-

scribe two plates which are typical of the problems found in industrial and architectural acoustics.

84-2717
Vibration of Four-Sides Supported One-Way Continuous Rectangular Orthotropic Elastic Plates with Added Masses

Zhang Wohua and Xu Zhixin
J. of Tung-Chi Univ., (2), pp 26-40 (1983)
CSTA No. 624-83.109

Analytic solutions for the natural frequency and mode of a one-way continuous four-sides supported rectangular orthotropic elastic plate with added masses and the steady response of the plate with complex damping under harmonic excitation are presented.

84-2718
Stability and Vibrations of Geometrically Nonlinear Cylindrically Orthotropic Circular Plates

D. Shilkrut
The Pearlstone Ctr. for Aeronautical Engrg. Studies, Ben-Gurion Univ. of the Negev, Beer Sheva, Israel, J. Appl. Mech., Trans. ASME, 51 (2), pp 354-360 (June 1984) 7 figs, 13 refs

The stability analysis of axisymmetrical equilibrium states of geometrically nonlinear, orthotropic, circular plates that are deformed by multiparameter loading, including thermal influence, is presented. The dynamic method (method of small vibrations) is used to accomplish this purpose. The behavior of the plate in different cases is revealed.

84-2719
On the Resonance Frequencies of Water-Loaded Circular Plates

F.M. de Espinosa and J.A. Gallego-Juarez
Laboratorio de Ultrasonidos, Instituto de Acustica, Consejo Superior de Investigaciones Cientificas,
Serrano 144, Madrid-6, Spain, J. Sound Vib., 94 (2), pp 217-222 (May 22, 1984) 2 figs, 2 tables, 9 refs

The studies on the increase of inertia, and the corresponding reduction in frequency, of plates when vibrating in water have been confined mainly to the lower modes of vibration and for plate radii much less than a wavelength of sound in the fluid. In this paper, a method is presented which, subject to certain approximations, permits the evaluation of the influence of the fluid on the frequency of any vibration mode whose deflection curve in a vacuum is known. The method has been applied to water-loaded circular plates vibrating in their axisymmetric modes.

84-2720
Nonlinear Transient Response of Isotropic Circular Plates

P.C. Dumir, Y. Nath, and M.L. Gandhi
Indian Inst. of Tech., New Delhi-110016, India, Computer Struc., 18 (6), pp 1009-1018 (1984) 12 figs, 1 table, 9 refs

The nonlinear transient response for stresses and deflection of thin linear elastic circular plates subjected to different time-dependent loads is investigated. Space-wise discretization is done using the collocation method with the zeros of a Chebyshev polynomial as collocation points. Newmark-β scheme is used for time-marching. Time and space-wise convergence studies are carried out. Both the linear and nonlinear transient response of clamped and simply supported circular plates under six different sets of transient loads are obtained.

84-2721
Dynamic Response of a Prestressed, Orthotropic Thick Plate Strip to a Moving Line Load

S. Chonan
The Univ. of British Columbia, 2324 Main Mall, Vancouver, Canada, J. Sound Vib., 93 (3), pp 427-438 (Apr 8, 1984) 6 figs, 10 refs

A study of the steady state response of an orthotropic plate strip to a moving line load is presented. The plate is of

infinite length and subjected to initial-in-plane stresses parallel and perpendicular to the edges. The solution is obtained on the basis of a thick plate theory which takes into account the effects of shear deformation and rotatory inertia. The critical speed of the load which brings about a resonance effect in the system is determined. Further, the bending moment in the plate is calculated for several values of the load speed and the initial stress parameters and shown graphically as a function of the space variable moving with the load.

Application of these ideas to acoustic emission source characterization is discussed.

84-2724
Non-Linear Transient Response of Flat Plate to Air Shock Wave
J.N. Lee
Naval Postgraduate School, Monterey, CA, 121 pp (Dec 1983)
AD-A140 491

84-2722
Free Vibration Analysis of Rectangular Cantilever Plates with Symmetrically Distributed Point Supports Along the Edges
H.T. Saliba
Univ. of Ottawa, Ottawa, Ontario K1N 6N5, Canada, J. Sound Vib., 94 (3), pp 381-395 (June 8, 1984) 6 figs, 3 tables, 6 refs

Key Words: Plates, Transient response, Shock waves, Computer programs

The nonlinear elasto-plastic response of a clamped flat plate to a typical air shock wave is investigated. The nonlinear effects of the plate responses due to the material and geometric nonlinearity are studied. The necessity of the modification of old armored vehicles is reviewed and the NASTRAN code is employed. The theoretical background of the nonlinear transient analysis is described, a step by step procedure of analyzing the dynamic load problem by shock wave using NASTRAN code is developed, and sensitivity analyses are performed.

Key Words: Plates, Cantilever plates, Free vibration, Method of superposition

Through exploitation of the superposition method, a highly accurate analytical solution is provided for the free vibration problem of rectangular cantilever plates with symmetrically distributed point supports along the free edges. Tables of eigenvalues for a wide range of plate aspect ratio are provided.

SHELLS
(Also see No. 2737)

84-2725
Vibration and Damping Analysis of a Multilayered Cylindrical Shell, Part I: Theoretical Analysis
N. Alam and N.T. Asnani
Aligarh Muslim Univ., Aligarh, India, AIAA J., 22 (6), pp 803-810 (June 1984) 1 fig, 11 refs

84-2723
Diffuse Waves in Finite Plates
R.L. Weaver
Univ. of Illinois at Urbana-Champaign, Urbana, IL 61801, J. Sound Vib., 94 (3), pp 319-335 (June 8, 1984) 4 figs, 17 refs

Key Words: Shells, Cylindrical shells, Layered materials, Vibration analysis, Layered damping

Key Words: Plates, Power spectral density, Acoustic emission, Sound waves, Wave propagation

The diffuse field assumption of room acoustics is shown to lead to a relationship between the total spectral energy density of a linear elastic wave disturbance in a finite plate and the power density as observed on the surface. For times long compared with acoustic transit times across the length of the plate, the diffuse field assumption allows the theorist to neglect the details of edge reflections under the assumption that an eventual steady state energy balance is maintained among the different branches of wave propagation.

The governing equations of motion for the nonaxisymmetric and axisymmetric variational of a general multilayered cylindrical shell having an arbitrary number of orthotropic material layers are derived using variational principles. The refined analysis considers bending, extension, and shear deformations in all layers of a multilayered cylindrical shell, including rotary and longitudinal translatory as well as transverse inertias. The solution for a radially simply supported shell is obtained and the procedure for determining the damping effectiveness in terms of the system loss factor for all families of the modes of vibration in a multilayered shell with elastic and viscoelastic layers is reported.

84-2726
Dynamic Instability of a Circular Cylindrical Shell Subjected to a Simultaneous Action of Compressive Forces and Temperature Field, Both Periodical in Time

C.V. Massalas
Univ. of Ioannina, Greece, Rev. Roumaine Sci. Tech., Mecanique Appl., 29 (2), pp 159-171 (Mar/Apr 1984) 7 figs, 6 refs

Key Words: Shells, Cylindrical shells, Dynamic stability, Axial excitation, Temperature effects

The problem of the dynamic stability of a clamped cylindrical shell subjected to the simultaneous action of longitudinal compressive forces and temperature field, both periodical in time, in the case of the temperature-dependent modulus of elasticity, is formulated on the basis of Donnell's linear theory and Galerkin's method. Numerical results for the vibration frequencies, buckling load and the boundaries of the principal instability regions are presented and the influence of the temperature field on them is extensively discussed.

84-2727
Natural Frequencies of Fluid-Coupled Circular Cylindrical Shells (Eigenschwingungen von Durch Flüssigkeit Gekoppelten Kreiszylinderschalen)

Nguyen-Xuan-Hung
Polytechnic Institute of Hanoi, Vietnam, Rev. Roumaine Sci. Tech., Mecanique Appl., 29 (1), pp 31-49 (Jan/Feb 1984) 19 figs, 4 refs
(In German)

Key Words: Shells, Cylindrical shells, Fluid-filled containers, Submerged structures, Natural frequencies

Natural frequencies of two fluid-coupled circular cylindrical shells are investigated. Special cases, namely, vibration of fluid-filled and submerged shells, are compared with experimental results.

84-2728
Acoustic Scattering from Air-Filled Cylindrical Shells in Water (Diffusion d'une onde ultrasonore par des tubes remplis d'air immerges ans l'eau)

G. Maze, J. Ripoche, A. Derem, and J.L. Rousselot
Universite de Haute Normandie, Laboratoire d'Electronique et d'Automatique, groupe "Ultrasons," U.E.R.S.T., Place Robert Schuman, 76610 Le Havre, Acustica, 55 (2), pp 69-85 (May 1984) 25 figs, 39 refs
(In French)

Key Words: Shells, Cylindrical shells, Submerged structures, Underwater sound, Sound waves, Wave scattering

The Resonance Isolation and Identification Method (RIIM) allows a direct verification of the Resonance Scattering Theory (RST). The resonance spectra (recording of the backscattered echo versus the frequency just after the excitation) of aluminum elastic cylinders and cylindrical shells insonified by a plane acoustic wave are quasi-linear. Resonances result from standing waves on the circumference of the cylinder. These standing waves originate from surface waves which propagate around it in two opposite directions. The mode number also is determined by experimentation (RIIM).

84-2729
Non-Stationary Response of Non-Linear Liquid Motion in a Cylindrical Tank Subjected to Random Base Excitation

M. Sakata, K. Kimura, and M. Utsumi
Tokyo Inst. of Tech., Meguro-ku, Tokyo 152, Japan, J. Sound Vib., 94 (3), pp 351-363 (June 8, 1984) 6 figs, 1 table, 11 refs

Key Words: Cylindrical shells, Tanks (containers), Fluid-filled containers, Storage tanks, Base excitation, Random excitation, Seismic excitation

The nonstationary response of nonlinear liquid motion in a cylindrical tank subjected to lateral earthquake excitation is investigated by modeling the earthquake excitation as an amplitude modulated non-white random process having a dominant frequency. The nonstationary standard deviation and mean responses of the liquid surface displacement are calculated and it is shown that the linear liquid motion theory is not necessarily sufficient to evaluate the safety of tanks, since the nonlinear analysis leads to a positive value of the mean response for the liquid surface displacement at the tank wall, while the linear theory predicts zero mean response.

84-2730
Dynamic Behavior of Liquid Free Surface in a Cylindrical Container Subject to Vertical Vibration

H. Hashimoto and S. Sudo

Inst. of High Speed Mechanics, Tohoku Univ., Sendai, Japan, Bull. JSME, 27 (227), pp 923-930 (May 1984) 17 figs, 15 refs

Key Words: Cylindrical shells, Fluid-filled containers, Sloshing

A series of experimental studies on the dynamic behavior of the gas-liquid interface are reported. These studies are concerned with the liquid sloshing phenomena induced by vertical vibration of a cylindrical container. The disappearance of the harmonic surface wave motion, the formation of 1/2-subharmonic motion, the mechanism of the surface disintegration and the behavior of spray-excited low frequency waves are investigated.

84-2731
Axisymmetric Vibrations of Thick Shells of Revolution

K. Suzuki, T Kosawada, and S. Takahashi
Yamagata Univ., Yonezawa, Japan, Bull. JSME, 27 (227), pp 980-986 (May 1984) 9 figs, 10 refs

Key Words: Shells, Shells of revolution, Axisymmetric vibrations, Natural frequencies, Mode shapes, Transverse shear deformation effects, Rotatory inertia effects

Using an improved thick shell theory, the axisymmetric vibrations of barrel-like shells of revolution are analyzed. The equations of vibration are solved exactly by a series solution. Natural frequencies and mode shapes of symmetric shells of revolution with both ends clamped and with both ends simply supported are obtained.

84-2732
Nonlinear Interactions in Resonance Response of Thin Shells

A. Tesar
Inst. of Structures and Architecture, Slovak Academy of Sciences, Bratislava, Czechoslovakia, Computer Struc., 18 (6), pp 1047-1055 (1984) 10 figs, 9 refs

Key Words: Shells, Resonant response, Nonlinear theories

The transfer matrix analysis of nonlinear dynamic response of stiffened thin shells in resonance regions of vibration are presented. Considered is the interaction of geometric and physical nonlinearities. Direct time integration procedures to solve the equations of motion are used. Corresponding incremental transfer matrices are formulated in an updated Lagrangian reference mesh.

84-2733
Thin Shell Theories and Acoustic Wave Scattering by Infinitely Long Cylindrical Shells of Arbitrary Cross Section

S. Baskar, V.V. Varadan, and V.K. Varadan
Ohio State Univ., Columbus, OH 43210, J. Acoust., Soc. Amer., 75 (6), pp 1673-1679 (June 1984) 8 figs, 1 table, 12 refs

Key Words: Shells, Sound waves, Wave scattering

The scattering of acoustic waves by an infinitely long cylindrical shell immersed in a fluid is analyzed. A new approach has been proposed using thin shell theory incorporating the impedance of the shell in the T-matrix formulation. Numerical results are presented for the farfield backscattering amplitude as a function of frequency. Calculations were made for infinitely long circular and elliptic cylindrical shells immersed in water for various shell thicknesses for waves incident at an arbitrary angle in the plane normal to the axis of the cylinder. The impedance resulting from the use of various shell theory approximations for circular cylindrical shells is presented.

84-2734
Some Problems of Stability of Propagation of Non-Linear Waves in Shells and Plates

A.G. Bagdoev and L.A. Movsisian
Inst. of Mechanics of the Academy of Sciences of Armenian S.S.R., Yerevan, U.S.S.R., Intl. J. Nonlin. Mech., 19 (3), pp 245-253 (1984) 1 fig, 12 refs

Key Words: Shells, Plates, Fluid-induced excitation, Stability

Equations of modulations, taking into account the second order derivatives of amplitude and stability conditions, are obtained. The general results are applied to the stability problems of propagation of quasimonochromatic waves in plates, shells, plates in contact with fluid, shells containing fluid, plate in magnetic field, tree-layered plate and visco-elastic plate.

84-2735
Exact Solutions of Moderately Thick Laminated Shells

J.N. Reddy

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, ASCE J. Engrg. Mech., 110 (5), pp 794-809 (May 1984) 2 figs, 7 tables, 28 refs

Key Words: Shells, Layered materials, Fundamental frequency

An extension of the Sanders shell theory for doubly curved shells to a shear deformation theory of laminated shells is presented. The theory accounts for transverse shear strains and rotation about the normal to the shell midsurface. Exact solutions of the equations are presented for simply supported, doubly curved, cross-ply laminated shells under sinusoidal, uniformly distributed, and concentrated point load at the center. Fundamental frequencies of cross-ply laminated shells are also presented.

84-2736
Complex Response Analysis of Shells of Revolution Including Uniform Base Translation and Rocking
Bor-Jen Lee and P.L. Gould
Washington Univ., St. Louis, MO, Earthquake Engrg. Struc. Dynam., 12 (4), pp 507-519 (July/Aug 1984) 16 figs, 1 table, 8 refs

Key Words: Shells, Interaction: soil-structure, Substructuring methods

A complex response algorithm for the dynamic analysis of axisymmetric thin shells supported on an interactive foundation is developed. The substructure deletion method is employed through the utilization of a dynamic boundary system at the contact area between the superstructure and the substructure. A new mathematical formulation in conjunction with the shell behavior is developed to deal with rigid body motions due to the negation of the fixed base assumption. Four foundation conditions are considered to examine the effect of base flexibility on the seismic response of cooling towers.

PIPES AND TUBES

84-2737
Acoustic Spectrogram and Complex-Frequency Poles of a Resonantly Excited Elastic Tube
G.C. Gaunaurd and D. Brill
Naval Surface Weapons Ctr., R-43, White Oak, Silver Spring, MD 20910, J. Acoust. Soc. Amer., 75 (6), pp 1680-1693 (June 1984) 19 figs, 30 refs

Key Words: Tubes, Cylindrical shells, Shells, Sound waves, Wave scattering

A study of the resonance scattering undergone by an air-filled hollow elastic cylinder excited by an incident plane acoustic wave is presented. The boundary value problem is constructed, its classical solution, based on the resonance scattering theory is obtained, and a variety of useful computed results are generated.

84-2738
Interactions Between Self and Parametrically Excited Motions in Articulated Tubes
A.K. Bajaj
Purdue Univ., West Lafayette, IN 47907, J. Appl. Mech., Trans. ASME, 51 (2), pp 423-429 (June 1984) 4 figs, 22 refs

Key Words: Tubes, Fluid-filled containers, Self-excited vibrations, Parametric vibration

The nonlinear dynamics of a two-segment articulated tubes system conveying a fluid is studied when the flow is harmonically perturbed. The mean value of the flow rate is near its critical value when the downward vertical position gets unstable and undergoes Hopf bifurcation into periodic solutions. The harmonic perturbations are assumed to be in parametric resonance with the linearized system. The method of Alternate Problems is used to obtain the small nonlinearized subharmonic solutions of the system.

84-2739
Guidelines for the Instability Flow Velocity of Tube Arrays in Crossflow
S.S. Chen
Components Tech. Div., Argonne National Lab., Argonne, IL 60439, J. Sound Vib., 93 (3), pp 439-455 (Apr 8, 1984) 6 figs, 6 tables, 36 refs

Key Words: Tube arrays, Fluid-induced excitation

Fluid flowing across a tube array can cause dynamic instability. Once large-amplitude oscillations occur, severe damage may result in a short time. Such instability must be avoided in design. This paper presents a brief review of different instability models and stability maps developed based on a semi-analytical model and published experimental data.

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84-2740

The Effect of Tube Mass on the Flow Induced Response of Various Tube Arrays in Water

D.S. Weaver and H.C. Yeung

McMaster Univ., Hamilton, Ontario, Canada, J. Sound Vib., 93 (3), pp 409-425 (Apr 8, 1984) 12 figs, 3 tables, 17 refs

Key Words: Tubes, Heat exchangers, Fluid-induced excitation, Geometric effects

Experiments were run in a water tunnel to study the effect of mass ratio on the cross-flow induced response of heat exchanger tube arrays with a pitch ratio of 1.5. All four standard tube array geometries were examined and three different tube masses were used for each geometry. Response curves and frequency data are presented including Strouhal numbers, vorticity resonance amplitudes and fluidelastic stability thresholds.

84-2741

Seismic Performance Evaluation of Lifelines

L.R.L. Wang and Y.H. Yeh

Univ. of Oklahoma, Norman, OK, Rept. No. LEE-005, NSF/CEE-82112, 122 pp (Nov 1982) PB84-184175

Key Words: Lifeline systems, Seismic response

Experimental methods suitable for either overall or parametric seismic performance evaluation of lifeline systems are summarized. Ground motion characteristics, called the most influential parameter of all lifeline systems, are examined. Active field testing methods, passive field testing methods, and laboratory testing methods of below-ground systems are described. Parameters of importance to buried lifeline systems, such as lateral and longitudinal soil resistance characteristics and joint resistant behavior, are discussed. For above-ground lifeline systems, seismic observations, field testings, and model testing of bridges, above-ground pipelines, and communication lifelines are presented.

DUCTS

84-2742

Experiments on Sound Radiation from a Duct with a Circumferentially Varying Liner

C.R. Fuller and R.J. Silcox

NASA Langley Res. Ctr., Hampton, VA, AIAA J., 22 (6), pp 781-785 (June 1984) 11 figs, 1 table, 9 refs

Key Words: Ducts, Acoustic linings, Sound waves, Wave radiation

The radiation of sound from an asymmetrically lined duct is experimentally studied for various hard-walled standing mode sources. Measurements were made of the directivity of the radiated field and amplitude reflection coefficients in the hard-walled source section. These measurements are compared with baseline hard-wall and uniformly lined duct data. The dependence of these characteristics on mode number and angular location of the source is investigated. A comparison between previous theoretical calculations and the experimentally measured results is made.

84-2743

Design and Flight Test of a Kevlar Acoustic Liner

H.C. Lester, J.S. Preisser, and T.L. Parrott

NASA Langley Res. Ctr., Hampton, VA, J. Aircraft, 21 (7), pp 491-497 (July 1984) 9 figs, 5 tables, 14 refs

Key Words: Ducts, Acoustic linings, Noise reduction, Turbofan engines, Turbofans

The design, fabrication, and flight evaluation of a Kevlar acoustic liner for a JT15D turbofan engine are summarized. The liner was designed to suppress by a measurable amount a dominant BPF tone. This tone or spinning mode was produced for research purposes by installing 41 circumferentially-distributed small-diameter rods upstream of the 28 fan blades. Duct liner attenuations calculated by a finite-element procedure are compared to far-field power (insertion) losses deduced from flight data. The finite-element program modeled the variable geometry of the JT15D inlet and used a uniform flow with a boundary layer roll-off to model the inlet flowfield.

84-2744

Geometry and Static Flow Effects on Acoustic Radiation from Ducts

R.J. Silcox

NASA Langley Res. Ctr., Hampton, VA, AIAA J.,

48

22 (8), pp 1087-1093 (Aug 1984) 11 figs, 3 tables, 10 refs

Key Words: Ducts, Sound waves, Wave propagation

An experimental study of the effects of geometry, flow, frequency, and source structure on the radiation and reflection of sound from duct inlets has been conducted. This work extends a previous study by comparing two inlet shapes typical of static and flight testing and by considering higher-order radial modes. Measurements of the internal and radiated acoustic fields are presented in terms of modal reflection coefficients and absolute radiated pressure directivity.

Imperial Valley earthquake. Response of the structure during the earthquake was recorded by 13 strong-motion accelerographs. Vertical-load-carrying and lateral-force-resisting systems are described, and corrected acceleration records, calculated base shear and moment waveforms, response spectra, and Fourier amplitude spectra are presented.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 2664, 2665, 2737, 2764)

84-2745

A Study of Active Control of Noise in Ducts

J. Tichy, G.E. Warnaka, and L.A. Poole
Pennsylvania State Univ., State College, PA 16801,
J. Vib., Acoust., Stress, Rel. Des., Trans. ASME,
106 (3), pp 399-404 (July 1984) 4 figs, 2 tables,
9 refs

Key Words: Noise reduction, Ducts, Active control

Some new theoretical results on the development of a one-dimensional noise cancellation system in a duct are presented. There are several parts of the actual system design: the generation of the cancelling sound field and the placement of the feedback microphone, the design of the adaptive filter and the considerations including the system stability. This paper concentrates on the analysis of the sound field in a direct relationship with the feedback microphone position.

84-2747

Noise Reduction in Sheet Metal Manufacture (Lärmminderung bei der Blechverarbeitung)

P. Grund
VDI-Z., 126 (10), pp 337-344 (May 1984) 12 figs,
9 refs
(In German)

Key Words: Noise reduction, Industrial facilities

A systematic procedure for the reduction of noise in the sheet metal industry is described. Means for the determination of main noise sources are listed and the prevailing ones in sheet metal industry are discussed. In addition, silent production means such as silent hammers and grinding wheels, and alternative production methods to replace noisy manufacturing procedures are presented.

BUILDING COMPONENTS

84-2746

An Experimental/Analytical Study of the Dynamic Response of Staggered Structural Wall Systems

M.E. Kreger
Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign,
339 pp (1983)
DA8409974

Key Words: Walls, Earthquake response, Experimental data

The Imperial County Services Building of El Centro, California sustained severe damage during the 15 October 1979

84-2748

A Numerical Method for Ocean-Acoustic Normal Modes

M. Porter and E.L. Reiss
Northwestern Univ., Evanston, IL 60201, J. Acoust.
Soc. Amer., 76 (1), pp 244-252 (July 1984) 3 figs,
11 tables, 13 refs

Key Words: Sound waves, Wave propagation, Oceans, Normal modes, Finite difference technique

The method of normal modes is frequently used to solve acoustic propagation problems in stratified oceans. The propagation numbers for the modes are the eigenvalues of the

boundary value problem to determine the depth dependent normal modes. Errors in the numerical determination of these eigenvalues appear as phase shifts in the range dependence of the acoustic field. Such errors can severely degrade the accuracy of the normal mode representation, particularly at long ranges. A fast finite difference method to accurately determine these propagation numbers and the corresponding normal modes is presented.

84-2749

The First Order Non-Linear Sound Field of a Two-Frequency Spherical Source

S.M. Baxter

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 94 (3), pp 337-349 (June 8, 1984) 31 refs

Key Words: Sound waves, Wave propagation

Nonlinear effects in the sound field of a two-frequency omnidirectional spherical source are discussed. The source is imbedded in an infinite uniform medium. Absorption and dispersion in the medium have an arbitrary dependence on frequency. The first order nonlinear correction to the pressure field is computed by using Westervelt's virtual sources approach. Advantages of the present solution are its simplicity of form, its applicability to broad parameter ranges, and the ease with which its qualitative behavior at large distances from the source can be studied.

84-2750

Acoustic Diffraction Analysis by the Impulse Response Method: A Line Impulse Response Approach

H. Lasota, R. Salamon, and B. Delannoy

Institut Industriel du Nord, C.N.R.S.E.R.A. 593, Valenciennes, B.P. 48, 59650 Villeneuve d'Ascq, France, J. Acoust. Soc. Amer., 76 (1), pp 280-290 (July 1984) 9 figs, 1 table, 33 refs

Key Words: Sound waves, Wave diffraction, Impulse response

Acoustic diffraction of plane impulsive waves is considered for free-field, baffled, and pressure release boundary conditions, in the case of an arbitrary spatial distribution of combined, amplitude-time delay modulation in an aperture. The method is based on the impulse response analysis of parallel aperture lines, the line impulse responses being then integrated to give an aperture impulse response. A closed-form, analytical expression is derived for lines having an arbitrary amplitude modulation. In the case of nonmodulated aper-

tures of an arbitrary shape, the aperture impulse response is also of an analytical form, directly involving the aperture contour line.

84-2751

Non-Linear Self-Excited Acoustic Oscillations in Cavities

J.J. Keller

Brown Boveri Res. Centre, CH-5405, Baden, Switzerland, J. Sound Vib., 94 (3), pp 397-409 (June 8, 1984) 7 figs, 8 refs

Key Words: Sound waves, Acoustic excitation, Self-excited vibrations, Cavities

Nonlinear acoustic oscillations in covered cavities, excited by a jet which is wall-bounded on one side, are discussed on the basis of a second-order theory. With the shear layer at the free edge of the jet considered as a simple (stable) vortex sheet the matching conditions between the acoustic wave fields in the jet and the cavity are introduced in a general second-order equation for wave fields in rectangular resonators. This procedure leads to a second-order wave equation containing a time lag. Solutions are computed with the help of an evolution scheme and compared with experiments.

84-2752

Wave Models of Turbulent Flow over Compliant Surfaces

J.E. Ffowcs-Williams

Cambridge Univ., Cambridge, UK, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 364-368 (July 1984) 3 figs, 4 refs

Key Words: Sound generation, Fluid-induced excitation, Turbulence

The mechanics by which sound evolves from unsteady boundaries and flow can be represented in acoustic analogies which provide a formal structure for analyzing the process of sound creation. The acoustic analogy of Lighthill has been the firmest foundation for modeling the jet noise problem. Studies of that problem have gradually increased in sophistication and scope to a point where the analogy itself has been developed to display characteristics that are novel and a little startling. This paper will describe some of the developments leading to notions that turbulence can be influenced by well-chosen external stimuli and speculate a little on areas where these effects might have significant practical applications.

84-2753

Long-Range Acoustic Scattering by Surface Inhomo-geneities Beneath a Turbulent Boundary Layer

D.G. Crighton

Univ. of Leeds, Leeds, UK, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 376-382 (July 1984) 16 refs

Key Words: Sound waves, Wave scattering, Turbulence, Fluid-induced excitation

The interaction of low frequency turbulent boundary layer eddies and acoustic power and the acoustic fields produced by it, are examined in detail in this paper for the inhomo-geneities represented by a simple line support rib, a simple point support rib, and an edge to a plane elastic plate, either with or without an adjacent rigid baffle, and with a range of edge conditions.

84-2754

Reverberation Times of Closed Sound Paths with Low Damping (Nachhallzeiten schwach gedämpfter geschlossener Wellenzüge)

W. Kuhl

Am Reisenbrook 7a, D-2000, Hamburg, 67, Germany, Acustica, 55 (3), pp 187-192 (June 1984) 10 figs, 10 refs
(In German)

Key Words: Sound waves, Reverberation, Damping

The reverberation time of the sound path perpendicular to two parallel plates can be calculated by adding three damping components. It is shown by two examples, how the reverberation time in rooms with low diffusivity can differ in one direction or in a part of the room from that in the diffuse sound field.

84-2755

Application of the BIE Method to Sound Radiation Problems Using an Isoparametric Element

A.F. Seybert, B. Soenarko, F.J. Rizzo, and D.J. Shippy
College of Engrg., Univ. of Kentucky, Lexington, KY 40506, J. Vib., Acoust., Stress, Rel. Des., Trans.

Key Words: Sound waves, Wave radiation

Th application of the Boundary Integral Equation (BIE) method for the numerical solution of radiation problems governed by Helmholtz's equation is discussed. An isoparametric element formulation is introduced in which both the surface geometry and the acoustic variables on the surface of the radiating body are represented by quadratic shape functions within the local coordinate system. A general result for the surface velocity potential is derived. This result includes the case where the surface may have a nonunique normal (e.g., at the edge of a body). The BIE method is used to obtain numerical solutions for three radiation problems involving spherical and cubical geometry.

84-2756

Recent Modeling of Turbulent Wall Pressure and Fluid Interaction with a Compliant Boundary

D.M. Chase

Chase, Inc., Cambridge, MA 02142, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 328-333 (July 1984) 15 refs

Key Words: Underwater sound, Boundary value problems

The relation of wall-pressure amplitude to fluctuating Reynolds-stress source amplitudes in the boundary layer is reviewed for inviscid, slightly compressible flow along a rigid planar boundary. An orthotropic wall-similarity model for source spectra is constructed and applied in this framework to derive a rough model for the wavevector-frequency spectrum of turbulent wall pressure, including radiative wave-numbers. By extension to a compliant boundary, with nonlinear, fluctuating Reynolds stress omitted, an expression is given for fluid-loading impedance and energy exchange in the presence of flow with arbitrary mean velocity profile, in terms of a solution to the homogeneous equation for pressure on a rigid wall.

SHOCK EXCITATION
(Also see Nos 2729. 2741)

84-2757

Psuedospectral Solutions of One- and Two-Dimensional Inviscid Flows with Shock Waves

L. Sakell

Naval Res. Lab., Washington, DC, AIAA J., 22 (7), pp 929-934 (July 1984) 22 figs, 5 refs

A new approach is presented for the utilization of pseudo-spectral techniques for the solution of inviscid flows with shock waves using the full Euler equations of motion. Artificial viscosity is applied together with low pass spectral filtering to damp out numerical oscillations that arise ahead of and behind the shock waves. Both second- and fourth-order artificial viscosity schemes are utilized. Solutions are presented for the one-dimensional propagating shock wave problem and for two-dimensional supersonic wedge flow.

84-2758
The Collapse of a Gas Bubble Near a Solid Wall by a Shock Wave and the Induced Impulsive Pressure
A. Shima Y. Tomita, and K. Takahashi
Inst. of High Speed Mechanics, Tohoku Univ., Sendai, Japan, IMechE Proc., 198 (8), pp 81-86 (1984) 6 figs, 16 refs

An experimental study concerning shock wave-bubble interaction was conducted in order to obtain a unified consideration of the mechanism of the impulsive pressure generation induced by the cavitation bubble collapse. It was found that the relation between the maximum impulsive pressure and the relative distance is closely similar to the known result obtained from a single spark-generated bubble.

84-2759
A Comparison of Approximate Techniques for Non-Linear Seismic Soil Response
A. Corsanego, G. Solari, and D. Stura
Istituto di Scienza delle Costruzioni, Univ. of Genova, Genova, Italy, Earthquake Engrg. Struc. Dynam., 12 (4), pp 451-466 (July/Aug 1984) 10 figs, 11 refs

Some equivalent linearization techniques, applicable to problems dealing with nonlinear seismic amplification of layered soils, are systematically treated and critically compared. The discussion concerns theoretical consistency, operative modali-

ties, computational complexity and numerical reliability of these methods.

84-2760
Low-Frequency Transfer of Seismic Energy by Superficial Soil Deposits and Soft Rocks
B. Mohammadioun and A. Pecker
Commissariat a l'Energie Atomique, Institut de Protection et de Sûreté Nucleaire, Département d'Analyse de Sûreté, CEN Fontenay-aux-Roses, B.P. No. 6, 92260 Fontenay-aux-Roses, France, Earthquake Engrg. Struc. Dynam., 12 (4), pp 537-564 (July/Aug 1984) 26 figs, 1 table, 26 refs

Recordings of recent strong earthquakes obtained on alluvial sites show that the maximum horizontal accelerations tend towards a limit of about 0.45 to 0.50g, associated with large displacements. By contrast, vertical accelerations do not appear to be subject to such a limit. Theoretical linear elasticity models, when applied to superficial layers of low strength, seem to be inadequate for the prediction of near-field ground motions in alluvial deposits.

VIBRATION EXCITATION
(Also see Nos. 2730, 2831)

84-2761
Javelin Dynamics with Measured Lift, Drag, and Pitching Moment
M. Hubbard and H.J. Rust
Univ. of California, Davis, CA 95616, J. Appl. Mech., Trans. ASME, 51 (2), pp 406-408 (June 1984) 3 figs, 8 refs

Optimal release conditions for the javelin are studied using computer simulation. Included are two important and realistic assumptions: initial velocity attainable by the thrower is dependent on the throwing angle, and the aerodynamic center of pressure moves as a function of angle of attack. Aerodynamic forces and moments, previously measured in wind tunnel tests, are incorporated in the simulation. Range contours are presented in the two-space of initial angle of attack -- initial flight path angle, assuming zero initial angular velocity.

84-2762

Dynamic Analysis of Plane Mechanisms with Multi Degrees of Freedom by Taking the Frame Vibration into Consideration (Zur Dynamischen Analyse Ebener Mechanismen Mit Mehreren Freiheitsgraden Unter Berücksichtigung der Gestellschwingungen)

Nguyen Van Khang

Polytechnische Hochschule Hanoi, Hanoi, Vietnam, Rev. Roumaine Sci. Tech., Mecanique Appl., 29 (1), pp 65-79 (Jan/Feb 1984) 3 figs, 6 refs
(In German)

Key Words: Vibration excitation, Frames, Mechanisms, Perturbation theory

The differential equation for the determination of the effect of small vibrations of a frame on the elastic members of a plane mechanism is presented. The conditions for dynamic stability and for periodic vibration of the mechanism are obtained by means of perturbation method.

84-2763

Excitation of Plates and Hydrofoils by Trailing Edge Flows

W.K. Blake

David W. Taylor Naval Ship R&D Ctr., Bethesda, MD, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 351-363 (July 1984) 20 figs, 2 tables, 28 refs

Key Words: Plates, Fluid-induced excitation

The flow-induced vibration of lifting surfaces is discussed from the perspective of the properties of the various flow regimes that exist on the surfaces. Depending on the Reynolds number and the geometry of the foil, the flow excitation may be tonal (generated by periodic vortex shedding) or random (generated by turbulent flow on the surface). Conditions are cited for the existence of vortex shedding excitation, and relationships are given for estimating the levels of flow-induced vibration to be expected from each flow source.

84-2764

The Influence of Surface Compliance on the Production of Sound by a Turbulent Boundary Layer

M.S. Howe

Univ. of Southampton, Southampton, UK, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 383-388 (July 1984) 1 fig, 20 refs

Key Words: Sound generation, Plates, Fluid-induced excitation, Underwater sound

The theory of aerodynamic sound in the form developed by Ffowcs-Williams and Hawkings is applied to investigate the production of sound by turbulent boundary layer flow over a thin, flexible plate. Conventional theories of boundary layer noise attribute the radiation to the boundary layer quadrupoles and their (passive) images in the plate, and neglect the interaction of turbulence with the finite amplitude motion of the plate caused by the wall pressure fluctuations. This interaction generates sound whose intensity is characteristic of aerodynamic sources of dipole type.

84-2765

Effects of Surface Irregularity on Turbulent Boundary Layer Wall Pressure Fluctuations

T.M. Farabee and M.J. Casarella

David W. Taylor Naval Ship Res. and Dev. Ctr., Ship Acoustics Dept., Bethesda, MD, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 343-350 (July 1984) 14 figs, 11 refs

Key Words: Turbulence, Boundary value problems, Fluid-induced excitation

Measurements were made of the mean velocity profiles and wall pressure field upstream and downstream of the flow over both a backward-facing and forward-facing step. For each configuration the velocity profiles show that the effects of the separation-reattachment process persist more than 24 step heights downstream of the step. Extremely high values of the RMS wall pressure are measured near reattachment. These values are 5 and 10 times larger than on a smooth flat plate for the backward-facing step and the forward-facing step, respectively.

84-2766

Estimation of the Wavevector-Frequency Spectrum of Turbulent Boundary Layer Wall Pressure by Multiple Linear Regression

Y.F. Hwang and F.E. Geib

David W. Taylor Naval Ship R&D Ctr., Bethesda, MD, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 334-342 (July 1984) 4 tables, 14 refs

Key Words: Turbulence, Boundary value problems, Fluid-induced excitation

The wavevector-frequency spectrum of the turbulent boundary layer wall pressure in the incompressive, inviscid domain in the intermediate and high frequencies range is examined. The rationale of using a linear regression model for estimating the normalized wavevector-frequency spectrum with a set of measured response data from a wavevector filter is presented.

84-2767

Unsteady Flow Concepts for Dynamic Stall Analysis

L.E. Ericsson and J.P. Reding

Lockheed Missiles & Space Co., Sunnyvale, CA, J. Aircraft, 21 (8), pp 601-606 (Aug 1984) 12 figs, 28 refs

Key Words: Airfoils, Stalling, Aerodynamic loads

It is well established that there is a strong coupling between airfoil motion and boundary-layer separation with attendant vortex shedding. Until now sufficient information has not been available to determine the relative importance of various unsteady flow effects, such as the time-varying inviscid pressure gradient and the unsteady viscous boundary condition at the wall, the moving wall effect. *Recent experimental results provide the needed information, revealing how the mode of oscillation for the airfoil determines which unsteady flow effect will dominate.*

84-2768

Application of Transonic Codes to Aeroelastic Modeling of Airfoils Including Active Controls

J.T. Batina and T.Y. Yang

Purdue Univ., West Lafayette, IN, J. Aircraft, 21 (8), pp 623-630 (Aug 1984) 12 figs, 3 tables, 25 refs

Key Words: Airfoils, Stability, Active control

A study is performed using aeroelastic modeling to investigate the stability behavior of airfoils in small-disturbance transonic flow. *Two conventional airfoils and a supercritical airfoil are considered. Three sets of unsteady aerodynamic data are computed using three different transonic codes for comparison purposes. Stability results obtained using a constant matrix, state-space, aeroelastic model are presented in a root-locus format.*

84-2769

Vibrations and Stability of Mechanical Systems: III

K. Huseyin

Univ. of Waterloo, Ontario, Canada N2L 3G1, Shock Vib. Dig., 16 (7), pp 15-22 (July 1984) 92 refs

Key Words: Vibration analysis, Stability, Reviews

This is the third review article concerning general developments in the area of vibrations and stability of mechanical systems. Advances that have been made since 1980 are described. The review covers both linear and nonlinear theories as well as basic methodology developed for holonomic autonomous mechanical (discrete) systems.

MECHANICAL PROPERTIES

DAMPING

84-2770

Constrained Layer Damping with Vitreous Enamel

B. Kumar and M.L. Drake

Univ. of Dayton Res. Inst., Dayton, OH 45469, J. Sound Vib., 93 (3), pp 389-395 (Apr 8, 1984) 6 figs, 2 tables, 5 refs

Key Words: Damping, Layered damping

The concept of constrained layer damping with vitreous enamel is experimentally evaluated. The constraining layer markedly broadens the free layer damping peak. The broadening is explained on the basis of two simultaneous energy dissipation mechanisms and is related to the vitreous enamel's loss factor and viscosity.

84-2771

Nonzero Mean Random Vibration of Hysteretic Systems

T.T. Baber

Univ. of Virginia, Charlottesville, VA 22901, ASCE J. Engrg. Mech., 110 (7), pp 1036-1049 (July 1984) 9 figs, 17 refs

Key Words: Hysteretic damping, Random excitation

A differential equation model for hysteretic systems is analyzed under nonzero mean random excitation. Under

certain conditions, a closed form linearization of the equations of motion is possible. Resulting mean and zero time lag covariance responses agree well with Monte Carlo response simulations. Generalization to degrading systems is straightforward. Skewness coefficients computed from simulation results indicate significantly asymmetric response.

interaction. The concepts involved are developed by reference to viscously damped single-degree-of-freedom systems, and numerical solutions are included to illustrate the accuracy and efficiency of the proposed procedure and its superiority over the classical discrete Fourier transform approach.

FATIGUE

84-2772

Modification Caused by Compliant Layers and Blankets in the Pressure Field Induced on a Boundary

G. Maidanik
David W. Taylor Naval Ship R&D Ctr., Bethesda, MD, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 369-375 (July 1984) 10 figs, 6 refs

Key Words: Structural modification techniques, Cladding, Layered damping

A primitive analytical tool to assess the modification in the response caused by introducing various combinations of flexible layers on panels is proposed and developed. The tool is primitive in the sense that quantities which characterize the dynamic system are expressed in terms of lumped parameters. The formalism is expressed in terms of a matrix that relates the response vector to an external drive vector that induces the response. An element of the matrix identifies the surface on which an external test drive is acting and the surface on which the resulting response is assessed. The general formalism is specialized to the case of a panel that is clad with a composite consisting of a compliant layer and a blanket.

84-2773

Efficient Analysis of Dynamic Response of Linear Systems

A.S. Veletsos and C.E. Ventura
Rice Univ., Houston, TX 77251, Earthquake Engrg. Struc. Dynam., 12 (4), pp 521-536 (July/Aug 1984) 4 figs, 2 tables, 8 refs

Key Words: Transient response, Interaction: soil-structure, Damped structures, Viscous damping

After reviewing briefly a recently proposed procedure for evaluating the dynamic transient response of a classically damped linear system from its corresponding steady-state response, a modified procedure is presented which also appears to be highly efficient for non-classically damped systems of the type encountered in studies of soil-structure

84-2774

Calculation of the Plasma Nitrated Structural Component Samples Taking into Consideration the Hardness Curve and Residual Stress (Berechnung der Dauerschwingfestigkeit von plasmanitrierten bauteilähnlichen Proben unter Berucksichtigung des Härte - und Eigenspannungsverlaufs)

K.H. Kloos and E. Velten
Institut f. Werkstoffkunde der Technischen Hochschule Darmstadt, Fed. Rep. Germany, Konstruktion, 36 (5), pp 181-188 (May 1984) 13 figs, 4 tables, 23 refs
(In German)

Key Words: Fatigue life, Internal stress, Hardness effects

Fatigue strength of boundary layer-stiffened structural components is considerably affected by the boundary hardness and residual stress in the near surface area. For the determination of a quantitative effect of these characteristics a procedure for the calculation of fatigue strength of plasma-nitrated structural component samples using numerous experimental data is derived. The calculated results agree well with the test data in spite of the multiplicity of parameters.

84-2775

Study on Crack Growth Behaviors in Impact Fatigue (Part II, Crack Closure Behaviour under Simple Impact Load)

H. Nakayama, Y. Kanayama, M. Shikida, and T. Tanaka
Osaka Industrial Univ., Nakagaito, Daito-city, Osaka, Japan, Bull. JSME, 27 (227), pp 854-861 (May 1984) 13 figs, 1 table, 23 refs

Key Words: Fatigue tests, Impact excitation, Crack propagation

Fatigue crack growth behavior was investigated under a simple impact stress pattern by using center-notched 0.1% C aluminum killed carbon steel plate specimens, and results obtained were discussed in comparison with those obtained under non-impact fatigue.

84-2776

Study on Characteristics of Fatigue Crack Propagation at Near-threshold Range and Its Affecting Factors

Yan Minggao

A review of the characteristics and mechanisms of fatigue crack propagation (FCP) at near-threshold range in various metals and alloys is presented. Experimental results from a series of microfractographic analyses of specimens and structures indicated that a type of crystallographic fracture occurs predominantly at near-threshold range. A correlation of the orientation of facets for different metals and alloys with lattice structures, SFS and modes of slip are described. The relation between the fatigue limits of plain- and notched-specimens and fatigue thresholds together with the mechanism of FCP behavior in short cracks is evaluated.

84-2777

Modeling Cyclic Deformation and Fatigue Behavior of Cast Iron under Uniaxial Loading

S.D. Downing

A model for estimating cyclic deformation behavior of cast iron under uniaxial loading is described. The model separates total response into components due to symmetrical elastic/plastic response in the matrix/graphite composite and to the nonlinear elastic response of the free graphite phase. Predictions are compared to experimental data for gray cast iron, compacted graphite cast iron and nodular iron. A continuum damage model for fatigue analysis of cast iron is also discussed. The model considers damage to be a global measure of surface crack growth.

ELASTICITY AND PLASTICITY

84-2778

Mode Conversion and Resonance Scattering of Elastic Waves from a Cylindrical Fluid-Filled Cavity

S.G. Solomon, H. Uberall, and K.B. Yoo
ORI, Inc., 1400 Spring St., Silver Spring, MD 20910,

Mode conversion and scattering of compressional and shear waves from cylindrical cavities are studied by performing partial wave expansions of the incident and scattered fields. Analysis, supported by extensive numerical calculations, shows that each partial wave spectrum consists of a smooth background identical to that of an empty cavity and a series of resonance terms associated with the eigenvibrations of the cavity's fluid interior. The scattering matrix for the cavity is defined and its unitary and symmetry properties are discussed. Argand diagrams of the trajectories of the S-matrix elements in the complex plane are shown to have certain easily recognized features which are associated with the cavity resonances.

84-2779

Some Thoughts on the Subject of Dynamic Elastic-Plastic Analyses of Rapid Crack Propagation and Crack Arrest

M.F. Kanninen

Despite the fact that the basic assumption of linear elastic fracture mechanics (LEFM) -- contained-yielding -- is violated for a crack that grows, most attempts to characterize rapid crack propagation and arrest are nevertheless rooted in LEFM. Starting from LEFM-based analysis procedures that form the current state-of-the-art, this paper attempts to provide some perspective for this evolutionary trend in dynamic fracture mechanics. Emphasized are some of the potential dilemmas that face the researchers pursuing this subject.

84-2780

Viscoelastic Effect on Dynamic Crack Propagation in Homalite 100

K.S. Kim, K.L. Dickerson, and W.G. Knauss

Illinois Univ. at Urbana-Champaign, IL, 21 pp (Oct 1983) Workshop on Dynamic Fracture held at Pasadena, CA, Feb 17-18, 1983, pp 205-225

AD-P003 115

Key Words: Crack propagation, Viscoelastic media

The optical method of caustics is used to determine the stress intensity factor for a running crack in a viscoelastic material. A formulation of the quasi-static deformation of materials with rheologically simple shadow-optic creep functions is derived for the caustics, solved numerically and applied to the fracture testing of Homalite-100 at various temperatures (40 deg C - 100 deg C). Theoretical and experimental caustics show good agreement in shape even for moderately high crack speeds (150 - 300 m/sec). Results also show that the relation between the stress intensity factor and the crack speed for Homalite 100 is highly sensitive to temperature variations.

84-2781

Dynamic, Steady-State Crack Propagation in Linear Isotropic Viscoelastic Material

J.R. Walton

Texas A&M Univ., College Station, TX, 8 pp (Oct 1983) Workshop on Dynamic Fracture held at Pasadena, CA, Feb 17-18, 1983, pp 197-204

AD-P003 114

Key Words: Crack propagation, Viscoelastic media

This paper is a summary of results of some recent analytical studies of dynamic, steady-state crack propagation in linear viscoelastic material. Closed form solutions are presented for the problems of a semi-infinite, anti-plane shear crack propagating with constant speed in an infinite general linear viscoelastic body and in a layer of finite thickness. For both boundary value problems, and for a general class of shear modulus, the solutions obtained exhibit a universal structure that depends in a simple way upon the time dependent shear modulus and crack speed. The forms for the solutions are convenient for the extraction of qualitative and quantitative information about the dependence of the stress field in the body upon the loading, the crack speed and the shear modulus.

84-2782

Path-Independent Integrals in Dynamic Fracture Mechanics

S.N. Atluri and T. Nishioka

Ctr. for the Advancement of Computational Mechanics, Georgia Inst. of Tech., Atlanta, GA, 13 pp (Oct 1983) Workshop on Dynamic Fracture held at Pasadena, CA, Feb 17-18, 1983, pp 156-168

AD-P003 111

Key Words: Crack propagation

Linear elastodynamic crack propagation under mixed mode non-steady conditions with an arbitrary velocity are considered.

84-2783

Some Theoretical Results on the Dependence of Dynamic Stress Intensity Factor on Crack Tip Speed

L.B. Freund

Brown Univ., Providence, RI, 8 pp (Oct 1983) Workshop on Dynamic Fracture held at Pasadena, CA, Feb 17-18, 1983, pp 129-136

AD-P003 109

Key Words: Crack propagation, Metals, Steel

Two specific topics are discussed under this common heading. The first is concerned with elastic-plastic crack growth and, in particular, with developing theoretical models to explain the dependence of dynamic fracture toughness on crack tip speed observed for 4340 steel and other high strength, low ductility materials which fail in a locally ductile manner. The second topic is concerned with limitations on the use of crack tip singular fields to describe actual stresses in elastic brittle materials during dynamic fracture. The problem discussed is the steady-state growth of a crack in the antiplane shear mode under small scale yielding conditions. Inertial resistance of the material is taken into account explicitly but, for steady state growth, the deformation is time independent as viewed by an observer fixed at the moving crack tip. Results are considered for two material models, elastic-ideally plastic and elastic-viscoplastic. According to the small scale yielding hypothesis, the (possibly non-linear) crack tip stress and deformation fields are controlled by the surrounding elastic field.

84-2784

Dynamic Crack Growth Criteria in Structural Metals

A.J. Rosakis, J. Duffy, and L.B. Freund

57

California Inst. of Tech., Pasadena, CA, 19 pp (Oct 1983) Workshop on Dynamic Fracture held at Pasadena, CA, Feb 17-18, 1983, pp 100-119
AD-P003 107

Analytical difficulties associated with the dynamic crack propagation problem have limited the available dynamic solutions to idealized situations. The major limitations introduced by these analytical solutions make both numerical methods and direct experimental observations necessary for the complete understanding of the dynamic fracture process. A principal purpose of experimental studies is to observe directly the instantaneous stress intensity factor as a function of crack speed, and to determine whether or not the observed variation constitutes a material characteristic. The present paper provides a description of dynamic crack propagation experiments on double cantilever beam specimens of a high strength steel. Measurements of the crack tip deformation field and of crack speed during propagation have been made using the optical method of caustics in reflection.

J.F. Kalthoff
Fraunhofer-Gesellschaft zuer Foerderung der Angewandten Forschung e.V., Freiburg im Bressau, Fed. Rep. Germany, Inst. fuer Werstoffmechanik, 25 pp (Oct 1983) Workshop on Dynamic Fracture held at Pasadena, CA, Feb 17-18, 1983, pp 11-35
AD-P003 102

The term fracture dynamics includes both crack tip motion effects and dynamic loading of cracks. Several topics are discussed regarding the subjects crack propagation, arrest of fact running cracks, time dependent loading in general, and loading of cracks by sharp stress pulses of short duration. Following the guidelines of the workshop, previous results are briefly summarized to state the current situation, but special consideration is given to still open questions and problems not yet resolved. Most experimental data reported in this paper have been generated by means of the shadow optical method of caustics. The caustics technique is an optical tool for measuring stress intensifications.

84-2785
Short Pulse Fracture Mechanics
D.A. Shockey, J.F. Kalthoff, H. Homma, and D.C. Erlich
SRI International, Menlo Park, CA, 15 pp (Oct 1983) Workshop on Dynamic Fracture held at Pasadena, CA, Feb 17-18, 1983, pp 57-71
AD-P003 105

A research effort was begun eight years ago at SRI International to analyze the response of a crack struck by a short-lived tensile pulse and to modify static fracture mechanics concepts to allow predictions of dynamic crack instability. The results of this work, which have been presented in a series of papers over the past six years, comprise a unified extension of classical fracture mechanics and are summarized here. Considerations of the stress intensity history experienced by a dynamically loaded crack tip are reviewed, and the instability criterion is considered.

84-2786
Some Current Problems in Experimental Fracture Dynamics

84-2787
Plate Impact Experiment for Studying Crack Initiation at Loading Rates K(1) Approximately 10(8) MPa m/s
R.J. Clifton and G. Ravichandran
Brown Univ., Providence, RI, 11 pp (Oct 1983) Workshop on Dynamic Fracture held at Pasadena, CA, Feb 17-18, 1983, pp 36-46
AD-P003 103

A symmetric plate impact technique is being developed for establishing the critical conditions for dynamic fracture initiation at extremely high loading rates. The specimen consists of a circular disc with a midplane, prefatigued, edge crack that has propagated halfway across the diameter. A compressive pulse propagates through the specimen, reflects from the rear surface, and subjects the crack plane to a step tensile pulse. The motion of the rear surface of the specimen is monitored with a laser interferometer system in order to determine the loading time required for crack extension to begin. Using this time in the elastodynamics solution of the stress wave diffraction problem, one can obtain the critical value of the stress intensity factor for dynamic fracture initiation.

WAVE PROPAGATION

EXPERIMENTATION

84-2788

Frequency-Dependent Elastic Properties of Rubber-like Materials with a Random Distribution of Voids

V.K. Varadan, V.V. Varadan, and Y. Ma

Ohio State Univ., Columbus, OH 43210, J. Acoust. Soc. Amer., 76 (1), pp 296-300 (July 1984) 9 figs, 23 refs

Key Words: Elastomers, Discontinuity-containing media, Frequency dependent parameters, Wave scattering

A self-consistent multiple scattering approach with suitable pair-correlation function has been employed to study the frequency-dependent properties of rubber materials containing a random distribution of voids. Numerical results indicate that for a certain range of concentration of voids, the resonance of the voids controls the frequency-dependent effective properties such that the imaginary part of the effective wavenumber becomes greater than the real part. This indicates that the propagating wave will be damped out over a distance smaller than a wavelength. The so-called "superviscous" propagation seems to occur over a bandwidth controlled by the concentration of voids.

84-2789

Experiments on Guided-Waves Propagation in Hetero-geneous Media (Expérimentations sur la propagation d'ondes guidées en milieu hétérogene)

M. Touratier

Ecole Nationale Superieure d'Arts et Metiers, 151 bd de l'Hopital, 75640 Paris Cedex 13, Acustica, 55 (2), pp 86-100 (May 1984) 15 figs, 14 refs
(In French)

Key Words: Wave propagation, Experimental data

An experimental study has been undertaken on two bi-metallic wave guides of rectangular section: a clad rectangular core and a three-layer. The frequency spectra is presented and the dependence of phase velocity with frequency is determined. For average frequencies, the propagation modes are strongly coupled. The existence of transition velocities and the aspect of distribution of relative acceleration in the final section of guides confirm that the fundamental mode of propagation is guided into a central region (core or central layer) at high frequencies. The comparison between experiments and theory is made on fundamental modes and the higher modes of propagation.

MEASUREMENT AND ANALYSIS

84-2790

Finite Element and Experimental Modeling of Three-Dimensional Annular-Like Acoustic Cavities Using the Normal Mode Approach

Chaw-Hua Charles Kung

Ph.D. Thesis, Ohio State Univ., 166 pp (1984)
DA8410394

Key Words: Cavities, Modal analysis, Finite element technique

Since closed form solutions for natural frequencies and modes of cavities are not possible, computational and experimental methods which are the main focuses of this study must be adopted. The scope of the study is limited to a linear system with zero mean flow and negligible temperature gradient; the frequency range of interest is approximately 0 - 2000 Hz for an air medium at room temperature and pressure. Two finite element methods, one using a variational method and the other employing a transient heat conduction analogy, are used for modal analysis of a number of cavities with emphasis on annular-like cavities; example cases studied include an acoustic column, a Helmholtz resonator, an acoustic ring, an acoustic disk, a pure annular cavity, and annular-like cavities. Condensation of the eigenproblems in the solution process is also considered. The results indicate that with carefully chosen meshes, the finite element models predict the first few modes of acoustic cavities accurately with moderate cost.

84-2791

Time-Domain Quasilinear Identification of Nonlinear Dynamic Systems

S.R. Ibrahim

Old Dominion Univ., Norfolk, VA, AIAA J., 22 (6), pp 817-823 (June 1984) 9 figs, 11 tables, 26 refs

Key Words: Modal analysis, System identification, Quasi-linearization technique, Time domain method

A time-domain linear modal identification technique is applied to identify some highly nonlinear dynamic systems. The modal concept is used to identify such nonlinear systems

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with the understanding that the *resulting modes are only* a mathematical representation of the series solution of the nonlinear system under consideration. Naturally, these identified modal parameters are not unique for nonlinear systems, *since they are functions of the systems' amplitudes* and hence referred to as quasilinear. The approach presented in this paper can be useful in predicting signs of nonlinearities when linearity is assumed. It can also be used to analyze and understand the types of nonlinearities in nonlinear systems through successive identifications at different levels of response.

equations, which are previously undefined in the literature, are a set of simultaneous cubic equations with constant coefficients. They can be solved by means of a converging iteration scheme to obtain all of the mode shapes. Each mode shape can be successively substituted back into Rayleigh's quotient to obtain the corresponding natural frequency. It is therefore possible to determine all of the mode shapes and natural frequencies of a system without developing or solving the characteristic polynomial.

84-2792

Ground Vibration Testing at Boeing

G.D. Carbon

Key Words: Modal analysis, Vibration tests, Experimental modal analysis, Random excitation, Aircraft

In the last four years, a number of improvements have been made in the techniques used to perform modal analysis tests on airplanes and other aircraft structures. These improvements are the result of a concentrated effort to reduce test time to a minimum through extensive use of computers and multiplexers in the data gathering and processing operations. The use of multiple shaker random excitation is discussed along with the data processing techniques required for interpreting these data. In addition to data gathering and processing this article discusses techniques used for mounting transducers, and a soft support system designed to separate the flexural modes from the rigid body modes of the airplane.

84-2793

The Modal Equations

A.E. Anuta, Jr.

Key Words: Modal analysis, Natural frequencies, Mode shapes, Rayleigh method, Iteration

For linear structural dynamics problems, an application of the minimizing properties of calculus to Rayleigh's quotient leads to the model equations of the system. The modal

84-2794

Frequency Analysis of Surfaces Machined Using Different Lubricants

L. DeChiffre

Key Words: Frequency analysis, Surface roughness, Lubrication

The paper is concerned with surface roughness analysis as a means of investigating lubricant action in cutting. An experimental setup involving a high-resolution signal analyzer has been used to obtain power spectrum characteristics, as well as conventional surface roughness parameters, of surfaces machined using different work materials and cutting fluids.

84-2795

A Phase Difference Technique for Acoustic Imaging

M. Hayama and K. Toda

Key Words: Acoustic imaging, Nondestructive tests

A method for obtaining C-scan images is reported by using a Lamb wave device with two arched interdigital transducers, in which the phase difference between an input signal as a reference and a delayed signal reflected at a sample surface or inside a test sample is detected as a function of the position. The transducers are used as a sound beam radiator or a detector at a liquid-solid interface. Acoustic imaging results are satisfactory in measuring the stress fields in ceramic samples.

84-2796

Estimation of Linearized Oil-Film Parameters from the Out-of-Balance Response

M.N. Sahinkaya and C.R. Burrows

Dept. of Dynamics and Control, Univ. of Strathclyde, Glasgow, Scotland, IMechE Proc., 198 (8), pp 131-134 (1984) 1 table, 10 refs

Key Words: Parameter identification technique, Rotors, Synchronous vibration

This paper outlines a simple approach to the identification of linearized oil-film characteristics from the rotor's synchronous response. The method is shown to be effective in filtering signal noise.

84-2797

Laser-Optical Measurement of Surface Distortion with Extreme Dynamic Loads (Laser-optisches Messen von Oberflächenauslenkungen bei extremdynamischen Belastungen)

F. Schubert

Laboratorium f. Mess- und Feinwerktechnik an der Hochschule der Bundeswehr Hamburg, Germany, Feinwerktech. u. Messtech., 92 (2), pp 83-84 (1984) 6 figs, 3 refs

(In German)

Key Words: Measurement techniques, Lasers, Optical methods, High frequencies

With extreme dynamic loads, surface movements occur with very small amplitudes and high velocity. The known path measuring methods are not really suited for the determination of such occurrences. The here given diffraction optical measuring procedure operates contact-free, can be easily adjusted and has the necessary resolution. Its critical frequency is only determined by the sensors and the digital storages. The basic usability of the method is proven using an example.

84-2798

Wiegand Effect Position and Velocity Sensors (Wiegand-Sensoren für Weg- und Geschwindigkeitsmessungen)

H.-J. Gevatter and G. Kuers

DODUCO KG Dr. Eugen Dürrwächter, Altgefall 12, D-7530 Pforzheim, Germany, Techn. Messen-TM,

51 (4), pp 123-129 (Apr 1984) 18 figs, 1 table, 3 refs

(In German)

Key Words: Vibration detectors, Measuring instruments, Magnetic fields

Wiegand effect position sensors have inherent insensitiveness against environmental conditions. The sensor device consists of several components optimal matched to the specific case of application. In addition the magnetic field for the Wiegand Effect Sensor can be generated by a permanent magnet or electromagnetically. That allows devices for the measurement of speed, position and angle of rotating and linear movement. The signal transmission is possible without power supply by two-wire circuit, but also wireless or by fiber optic with excellent signal to noise ratio.

84-2799

Incremental Linear Transducer Using Wiegand Sensors (Inkrementaler Lineargeber mit Wiegand- Sensoren)

N. Normann

DODUCO KG Dr. E. Durrwachter, Bereich Sensoren, Im Altgefall 12, D-7530 Pforzheim, Germany, Techn. Messen-TM, 51 (4), pp 130-132 (Apr 1984) 3 figs, 7 refs

(In German)

Key Words: Transducers, Vibration detectors

Wiegand sensors are suitable for applications under hostile environmental conditions. An incremental linear transducer which uses this sensor type and allows a long system length is described.

84-2800

Strain-Gauge Sensor with Frequency Output (DMS-Sensor mit Frequenzausgang)

B. Heck and D. Meyer-Ebrecht

Philips GmbH, Forschungslaboratorium Hamburg, Vogt-Kolln-Strasse 30, D-2000 Hamburg 54, Fed. Rep. Germany, Techn. Messen-TM, 51 (5), pp 171-175 (May 1984) 7 figs, 4 refs

(In German)

Key Words: Measuring instruments

A novel RC sine-wave oscillator circuit is described which is ideally suited for inexpensive but accurate sensor signal

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converters. Its oscillation frequency is controlled by a single attenuator element without effect on the oscillation amplitude. Applications of this oscillator as a converter for strain-gauge sensors have been investigated.

84-2801

Measurement Technology and Signal Processing (Messtechnik und Messsignalverarbeitung)

H.-R. Tränkler

Institut f. Mess.- und Regelungstechnik, Hochschule der Bundeswehr München, Werner-Heisenberg-Weg 39, D8014 Neubiberg, Fed. Rep. Germany, Techn. Messen.-TM, 51 (4), p 155 (Apr 1984)

(In German)

The topic of electronic signal processing will be featured in a series of monthly articles to be published over a period of two years. The articles will discuss the important elements of analog and digital measurement technology, its function in measurement systems, and a systematic correction and processing of the data. The series will be roughly subdivided under the following topics: A) An Introduction to Measurement Technology, B) Analog Measurement Techniques, C) Digital Measurement Techniques, D) Measurement Values -- Pick ups, E) Measuring Systems and Digital Data Processing, F) A Supplement to the Measurement Technology.

84-2802

Measurement Technology and Signal Processing. Introduction to Measurement Technology (Messtechnik und Messsignalverarbeitung. Einfuhrung in die Messtechnik)

H.-R. Tränkler

Inst. f. Mess.- und Regelungstechnik, Hochschule der Bundeswehr München, Werner-Heisenberg-Weg 39, D8014 Neubiberg, Fed. Rep. Germany, Tech. Messen.-TM, 51 (4), pp 155-158 (Apr 1984) 1 fig

(In German)

The first article of this series discusses the meaning of measurement and signal processing technology, the field of application and special problems, and the criteria for organizing the subject matter.

84-2803

Measurement Technology and Signal Processing. Analog Measurement Technology and Signal Processing (Messtechnik und Messsignalverarbeitung. Analoge Messtechnik und Messsignalverarbeitung)

H.-R. Trankler

Inst. f. Mess.- und Regelungstechnik, Hochschule der Bundeswehr München, Werner-Heisenberg-Weg 39, D8014 Neubiberg, Fed. Rep. Germany, Techn. Messen.-TM, 51 (5), pp 195-199 (May 1984) 6 figs, 7 refs (continued from April 1984)

(In German)

The output of analog data by means of a linear moving coil measuring system is discussed in this segment of the series. Because of the importance of analog data presentation and of linear moving coil instruments with external magnets, this type of measuring means is chosen as an example of linearly deforming measuring element. Also, the meaning of analog data is described. The article closes with a discussion of the physical effect, construction and production, the dimensioning of magnetic circuit, and several important static transfer characteristics of the moving coil measuring system.

84-2804

Measurement Technology and Signal Processing. Analog Measurement Technology and Signal Processing (Messtechnik und Messsignalverarbeitung. Analoge Messtechnik und Messsignalverarbeitung)

H.-R. Tränkler

Inst. f. Mess.- und Regelungstechnik, Hochschule der Bundeswehr München, Werner-Heisenberg-Weg 39, D8014 Neubiberg, Fed. Rep. Germany, Techn. Messen.-TM, 51 (6), pp 242-246 (June 1984) 7 figs, 2 refs (continued from May 1984)

(In German)

A number of characteristics are important for the evaluation of a measuring system. They are the static transfer properties (e.g., accuracy), the dynamic transfer properties (e.g., adjustment time), the reliability (e.g., rate of failure), and the cost and maintainability of the instrument. In this section the static transfer characteristics are discussed.

84-2805

Measurement Technology and Signal Processing. Analog Measurement Technology and Signal Processing (Messtechnik und Messsignalverarbeitung. Analoge Messtechnik und Messsignalverarbeitung)

H.-R. Tränkler

Inst. f. Mess- und Regelungstechnik, Hochschule der Bundeswehr München, Werner-Heisenberg-Weg 39, D8014 Neubiberg, Fed. Rep. Germany, Techn. Messen.-TM, 51 (7/8), pp 285-289 (July-Aug 1984) 5 figs, 8 refs (continued from June 1984) (In German)

Key Words: Measuring instruments, Signal processing techniques

Discrete and continuous data distribution, especially the Gaussian normal distribution, is discussed. The essential characteristics are mean value and standard deviation. The integration of distribution function gives the probability for the occurrence of data within a certain interval. Of particular practical importance is the confidence interval of the mean value in random tests and the graphic evaluation by means of probability system. Examples of application of statistical methods are given, e.g., propagation of random errors.

DYNAMIC TESTS

84-2806

Measuring Methods and Facilities in the Development Sector of Automobile Exhaust Mufflers (Messsystem in der Entwicklung von Automobilschalldämpfern)

P. Zacke

Schlierbacher Str. 62, D-7321 Albershausen, Germany, MTZ Motortech. Z., 45 (6), pp 239-243 (June 1984) 5 figs, 3 refs (In German)

Key Words: Exhaust systems, Mufflers, Test facilities, Measuring instruments, Computer-aided techniques

The rather craftman-like construction of exhaust mufflers as practiced in former times has turned to a sophisticated technology due to the growing environmental consciousness and resulting legal standards, the increased demands for comfort by the drivers and the pressure to save fuel on the one hand and to the immense advances in the engine construction sector and the ever increasing range of models offered by the automobile industry on the other hand. Now as before, one cannot dispense with experiments when developing automobile exhaust mufflers. A vehicle test stand and a computer-controlled measuring system render possible a quick exhaust gas noise analysis, particularly in the case of non-stationary operating conditions.

SCALING AND MODELING

84-2807

Scaling Methods for Earthquake Response Spectra

J.M. Nau and W.J. Hall

North Carolina State Univ., Raleigh, NC 27650, ASCE J. Struc. Engrg., 110 (7), pp 1533-1548 (July 1984) 6 figs, 4 tables, 25 refs

Key Words: Scaling, Seismic response spectra, Seismic design, Earthquake resistant structures

In current practice, design response spectra are normalized by the three peak ground motions. Alternative scaling factors are evaluated to reduce the dispersion encountered in normalized spectral ordinates. The scaling factors comprise two major groups, one based on ground motion data, and the other on response quantities. Within the group based on ground motion values are the integrals of the squared acceleration, velocity, and displacement, and the associated root-square, mean-square, and root-mean-square motions. Included within the group based on response quantities are the spectrum intensity and the mean Fourier amplitude. The scaling parameters are evaluated statistically using response spectra for elastic, elastoplastic, and bilinear hysteretic systems, computed from a set of twelve representative earthquake recordings. The results show that a three parameter system of spectrum intensities, computed within low, medium, and high frequency regions, may provide a better means of scaling earthquake response spectra. Significant reductions in dispersion may be realized if elastic spectra are normalized by the spectrum intensities rather than the peak ground motions. The spectrum intensities also reduce the scatter for normalized inelastic spectra, for low to moderate displacement ductilities.

DIAGNOSTICS
(Also see No. 2814)

84-2808

The Condition Monitoring of Rolling Element Bearings Using Vibration Analysis

J. Mathew and R.J. Alfredson

J. Mathew and Associates, Endeavor Hills, Victoria,

Australia, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (3), pp 447-453 (July 1984) 8 figs, 39 refs

Key Words: Diagnostic techniques, Bearings, Rolling contact bearings, Vibration analysis

A brief review on techniques of machine condition monitoring is presented followed by a description and results of a study involving the monitoring of vibration signatures of several rolling element bearings with a view to detect incipient failure. The vibration data were analyzed and several parameters were assessed with regard to their effectiveness in the detection of bearing condition. It was found that all the parameters were of some value depending on the type of bearing failure encountered.

84-2809
Troubleshooting In-Plant Equipment with Testing and Analysis
G.F. Mutch and R. Russell
GE-CAE International, Milford, OH, S/V, Sound Vib., 18 (6), pp 26-30 (June 1984) 18 figs

Key Words: Diagnostic techniques, Coal handling equipment

A general approach to solving noise, vibration or failure problems in installed process machinery is reviewed. The techniques are applied to a coal crusher that generated unacceptable levels of vibration. Analyses of the structure and implementation of recommended modification reduced the machinery vibration to satisfactory levels.

BALANCING

84-2810
Some Problems Connected with Balancing of Grinding Wheels
G. Gawlak
The Technical Univ. of Poznan, The Inst. of Mech. Engrg. Poznan, Poland, J. Engrg. Indus., Trans. ASME, 106 (3), pp 233-236 (Aug 1984) 5 figs, 8 refs

Key Words: Balancing techniques, Grinding machinery

In most publications, the unanimous opinion prevails that an increase of grinding machine vibration as well as deterioration

of workpiece quality are observed when the grinding wheel unbalance is on the increase. However, various data on the qualitative influence of wheel unbalance on the realization of the grinding process occur. In this paper a theoretical explanation of the influence of wheel unbalance on the dynamics of grinding, as well as the course and results of investigations proving theoretical considerations, are described.

MONITORING

84-2811
Acoustic Emission Monitoring of Corrosion Fatigue Crack Growth in Offshore Steel
C. Thaulow and T. Berge
Div. of Materials and Processes, Sintef, 7034 Trondheim-NTH, Norway, NDT Intl., 17 (3), pp 147-153 (June 1984) 12 figs

Key Words: Monitoring techniques, Acoustic emission, Corrosion fatigue, Off-shore structures

A research and development program has been carried out to establish relationships between corrosion fatigue crack growth in offshore steel qualities and acoustic emission. Laboratory experiments on small-scale specimens and wide plates have shown that when a certain combination of crack size and crack surface corrosion deposit thickness has been reached, high acoustic emission event rates, in the range of 10-40 events per fatigue cycle, are recorded. The main activity is recorded on rising load, generated from crack surface activity, e.g., secondary emission.

84-2812
Acoustic Emission Transducers for the Vibration Monitoring of Bearings at Low Speeds
P.D. McFadden and J.D. Smith
Univ. Engrg. Dept., Cambridge, UK, IMechE Proc., 198 (8), pp 127-130 (1984) 4 figs, 3 refs

Key Words: Monitoring techniques, Acoustic emission, Rolling contact bearings, Bearings

The use of acoustic emission transducers for the vibration monitoring of rolling element bearings at low speeds is explored. The frequency response and the base strain and bending sensitivities of the transducers are shown to be important.

84-2813

Experimental Observation of the Dynamic Behavior of Noncontacting Coned-Face Mechanical Seals

I. Etsion and I. Constantinescu

Technion, Haifa, Israel, ASLE, Trans., 27 (3), pp 263-270 (July 1984) 11 figs, 2 tables, 5 refs

Key Words: Monitoring techniques, Seals, Alignment

The dynamic behavior of a coned-face noncontacting seal is experimentally observed by means of three proximity probes monitoring the motion of the flexibly mounted stator. The various tilts of the stator are analyzed and the relative misalignment between stator and rotor is found. The effects of both the rotor runout and the flexible support on the relative misalignment are discussed. The tests demonstrate both stable and transition to unstable modes of seal operation. Reasons for failure and other phenomenon during stable seal operation are explained.

ANALYSIS AND DESIGN

ANALYTICAL METHODS
(Also see No. 2773)

84-2814

Diffraction of Elastic Waves by a Sub-Surface Crack (In-Plane Motion)

J.H.M.T. van der Hijden and F.L. Neerhoff

Dept. of Electrical Engrg., Lab. of Electromagnetic Res., Delft Univ. of Tech., P.O. Box 5031, 2600 GA Delft, The Netherlands, J. Acoust. Soc. Amer., 75 (6), pp 1694-1704 (June 1984) 18 figs, 1 table, 18 refs

Key Words: Cracked media, Wave diffraction, Elastic waves, Diagnostic techniques, Crack detection

A rigorous theory of the diffraction of time-harmonic elastic waves by an arbitrarily oriented, cylindrical, stress-free crack of finite width embedded in a semi-infinite elastic medium is presented. The incident wave is taken to be either a P wave, an SV wave, or a Rayleigh wave. The resulting boundary-value problems for the unknown jump in the particle displacement across the crack are solved by employing the integral-equation method in combination with the Galerkin method. Numerical results are presented in the form of scattering cross sections, normalized power scattering charac-

teristics, dynamic stress intensity factors, and Rayleigh wave transmission and reflection coefficients, for a range of geometrical parameters.

84-2815

FEM Subelements Conserve Computer Resources

T. Havas

Lockheed Missiles & Space Co., Palo Alto, CA, Mach. Des., pp 83-86 (July 26, 1984) 5 figs

Key Words: Finite element technique

A technique for defining repeating subassemblies of a structure, storing them off-line on computer disk memory, and reusing it over and over in model building, thus reducing the size of the finite element matrix, is described.

84-2816

The Loading-Frequency Relation of Linear Conservative Systems via a Direct Energetic (Action) Method

J.G. Papastavridis

Georgia Inst. of Tech., Atlanta, GA 30332, J. Sound Vib., 94 (2), pp 223-233 (May 22, 1984) 16 refs

Key Words: Eigenvalue problems, Linear systems

This paper presents alternative proofs of the well-known strict negative monotonicity and convexity properties of the fundamental frequency-load pair curve of the pure eigenproblem of free vibrations/buckling of linear conservative systems subject to a single loading parameter, by studying the first and second order variations of the system's Hamiltonian action (over the fundamental or highest eigenperiod), as one moves along the fundamental eigenpair curve.

84-2817

Dynamic Analysis of Structures Using Lanczos Coordinates

B. Nour-Omid and R.W. Clough

Center for Pure and Applied Mathematics, Univ. of California, Berkeley, CA 94720, Earthquake Engrg.

Struc. Dynam., 12 (4), pp 565-577 (July/Aug 1984)
4 figs, 1 table, 12 refs

A procedure for deriving the Lanczos vectors is explained and their use in structural dynamics analysis as an alternative to modal co-ordinates is discussed. The vectors are obtained by an inverse iteration procedure in which orthogonality is imposed between the vectors resulting from successive iteration cycles. Using these Lanczos vectors the equations of motion are transformed to tridiagonal form, which provides for a very efficient time-stepping solution. The effectiveness of the method is demonstrated by a numerical example.

84-2818
Dynamic Response Analysis of Linear Structural Systems Subject to Component Changes

A.R. Kukreti and C.C. Feng
Univ. of Oklahoma, Norman, OK 73069, Computer Struc., 18 (6), pp 963-976 (1984) 9 figs, 1 table, 21 refs

A method of analysis is developed for determining transient responses of large multiply-connected structural systems subjected to changes of structural components. A dynamic system is divided into two subsystems: the support which remains unaltered and the branch which is liable to change. The response characteristics of an original system are used as a basis for evaluating the new response of the altered system. The responses of the support interface coordinates due to external excitations on it are called base motion. The method is applied to a 16-story building rigid frame model. The methods give response results comparable with the conventional integrated system analysis. Approximations due to modal truncation are the same as component mode substitution method.

84-2819
The Gate Function Response Method in Analysis of Linear Systems

Du Qingxuan
J. of China Railway Society, 5 (4), pp 22-29 (1983)
CSTA No. 625.1-83.25

In this paper, the unit game function is defined and the gate function response method in the time-domain analysis of linear systems is introduced with the result that the convolution integral can be converted into ordinary integrals.

84-2820
A New Numerical Procedure for Symmetric Eigenvalue Problems

I. Levit
Tel-Aviv Univ., Ramat-Aviv, Israel, Computer Struc., 18 (6), pp 977-988 (1984) 3 figs, 7 tables, 15 refs

A numerical solution procedure for solving standard symmetric eigenvalue problems is presented. The solution is based on a sequence of one dimensional minmax stages and is capable of extracting eigenpairs in either decreasing or increasing orders. Generalized symmetric eigenvalue problems are transferred to standard form and solved using the same algorithm.

84-2821
A Method for Reducing the Order of Nonlinear Dynamic Systems

S.F. Masri, R.K. Miller, H. Sassi, and T.K. Caughey
Univ. of Southern California, Los Angeles, CA 90089-0242, J. Appl. Mech., Trans. ASME, 51 (2), pp 391-398 (June 1984) 11 figs, 26 refs

An approximate method that uses conventional condensation techniques for linear systems together with the nonparametric identification of the reduced-order model generalized nonlinear restoring forces is presented for reducing the order of discrete multidegree-of-freedom dynamic systems that possess arbitrary nonlinear characteristics. The utility of the proposed method is demonstrated by considering a redundant three-dimensional finite-element model half of whose elements incorporate hysteretic properties. A nonlinear reduced-order model, of one-third the order of the original model, is developed on the basis of wideband stationary random excitation and the validity of the reduced-order model is subsequently demonstrated by its ability to predict with adequate accuracy the transient response of the original nonlinear model under a different nonstationary random excitation.

84-2822

The Origin of Stability Indeterminacy in a Symmetric Hamiltonian

M.R. Hyams and L.A. Month

Dept. of Mech. Engrg., Univ. of California, Berkeley, CA 94720, J. Appl. Mech., Trans. ASME, 51 (2), pp 399-405 (June 1984) 4 figs, 5 refs

Key Words: Stability, Hamiltonian principle

The stability and bifurcation of periodic motions in a symmetric two-degree-of-freedom Hamiltonian system is studied by a reduction to a two-dimensional action-angle phase plane, via canonical perturbation theory. The results are used to explain why linear stability analysis will always be indeterminate for the in-phase mode in a class of coupled nonlinear oscillators.

84-2823

Dynamics of Gyroelastic Continua

G.M.T. D Eleuterio and P.C. Hughes

Univ. of Toronto, 4925 Dufferin St., Downsview, Ontario, Canada M3H 5T6, J. Appl. Mech., Trans. ASME, 51 (2), pp 415-422 (June 1984) 6 figs, 7 refs

Key Words: Gyroelastic properties, Continuum mechanics

This paper introduces the idea of distributed gyricity, in which each volume element of a continuum possesses an infinitesimal quantity of stored angular momentum. The continuum is also assumed to be linear-elastic. Using operator notation, a partial differential equation is derived that governs the small displacements of this gyroelastic contin-uum. Gyroelastic vibration modes are derived and used as basis functions in terms of which the general motion can be expressed. A discretized approximation is also developed using the method of Rayleigh-Ritz. The paper concludes with a numerical example of gyroelastic modes.

STATISTICAL METHODS

84-2824

Stochastic Combination of Load Effects

H.T. Pearce and Y.K. Wen

Univ. of Illinois at Urbana-Champaign, Urbana, IL 61801, ASCE J. Struc. Engrg., 110 (7), pp 1613-1629 (July 1984) 11 figs, 30 refs

Key Words: Stochastic processes, Load coincidence method

The problem of evaluating the probability that a structure becomes unsafe under a combination of loads over a given time period is addressed. The loads and load effects are modeled as either pulse (static problem) or intermittent continuous (dynamic problem) processes. The load coinci-dence method is extended to problems with both nonlinear limit states and dynamic responses. Results are compared with other methods, namely, methods based on upcrossing rate, simpler combination rules and Monte Carlo simulation. It is found that the load coincidence method is a versatile method for load combination of many types. It generally gives conservative results with good accuracy.

DESIGN TECHNIQUES

84-2825

Computer-Aided Design of Control Systems Dynamic Compensation

He Xungui and Chen Xianwei

Acta Automatic Sinica, 9 (4), pp 253-259 (1983) CSTA No. 629.8-83.40

Key Words: Design techniques, Computer-aided techniques, Frequency domain method

This paper presents a computer-aided design method for linear time-invariant system compensation in frequency domain. It can be applied to the compensation for control systems containing different origin poles, real zeros, real poles, and complex poles. Lead, lag, and lead-lag compensa-tions under given performance requirement can be achieved. The design result of the compensated parameters can be printed by the computer. It can also print the time response curves and performance for both the original systems and the compensated systems through computerized analysis, if necessary. Satisfactory results were obtained in many practi-cal cases.

COMPUTER PROGRAMS

84-2826

Development of a Simplified Procedure for Cyclic Structural Analysis

A. Kaufman

Key Words: Computer programs, Cyclic loading

Development was extended of a simplified inelastic analysis computer program for predicting the stress-strain history at the critical location of a thermomechanically cycled structure from an elastic solution. The program uses an iterative and incremental procedure to estimate the plastic strains from the material stress-strain properties and a plasticity hardening model. Creep effects can be calculated on the basis of stress relaxation at constant strain, creep at constant stress, or a combination of stress relaxation and creep accumulation. Good agreement was found between these analytical results and nonlinear finite-element solutions for these problems. The simplified analysis program used less than 1 percent of the CPU time required for a nonlinear finite-element analysis.

84-2827
Analytical and Experimental Investigation of Bird Impact on Fan and Compressor Blading
A.F. Storace, R.P. Minner, and R. Ravenhall
General Electric Co., Cincinnati, OH, J. Aircraft,
21 (7), pp 520-527 (July 1984) 19 figs, 14 refs

Key Words: Blades, Fan blades, Fans, Bird strikes, Computer programs

An analytical design tool and structural design criteria have been developed to assess and improve the foreign object damage tolerance of turbine engine fan and compressor blading. The analytical method is based on a three-dimensional finite element computer code that incorporates an interactive bird-loading model. The computer code and design criteria provide a systematic transient-structural analysis approach that will aid in the design of structurally efficient, impact damage-resistant blading.

84-2828
Pascal Packages for ASCII File I/O and CDC and Dynamic Strings
W.J. Vandeneersten
Physics Lab. RVO-TNO, The Hague, The Nether-
lands, Rept. No. PHL-1983-18, TDCK-77992, 47 pp
(May 1983)
N84-22285

Key Words: Computer programs

Three packages, written in PASCAL, that implement dynamic strings and ASCII file I/O in a structured way on CDC Cyber computers are described.

84-2829
AUTDYN -- A Digital Simulation Computer Program for the Handling Dynamics of Passenger Cars -- Part 2 (AUTDYN -- ein digitales Simulationsrechenprogramm für die Fahrdynamik von Personenkraftwagen -- Teil 2)
F. Uffelmann
Kammuhlweg 9, 8074 Gaimersheim, Germany, Auto-
mobiltech. Z., 86 (5), pp 243-246 (May 1984) 11
figs
(In German)

Key Words: Computer programs, Automobiles, Ride dynamics

This paper reports on the new AUTDYN vehicle model. The paper reports on steering system, tires, braking system, engine/transmission drive train, road surface and aerodynamics. The initial results of computation and comparisons with test measurements are presented in conclusion to show the applicability and validity of the model.

GENERAL TOPICS

TUTORIALS AND REVIEWS

84-2830
Some Dynamical Aspects of Army Missile Systems
J.J. Richardson
U.S. Army Missile Command, Redstone Arsenal, AL,
Shock Vib. Bull., No. 54, Pt. 1, pp 43-53 (June 1984)
17 figs (Proc. Shock Vib. Symp., Oct 18-20, 1983,
Jet Propulsion Lab., Pasadena, CA. Spons. SVIC,
Naval Res. Lab., Washington, D.C.)

Key Words: Missiles

The great diversity of size, employment, and flight parameters of army missile systems yield an accordingly diverse

set of dynamics problems. It is the aim of this paper to provide some indication of the range of these probelms. A few general remarks are followed by examples taken from recent experiences.

BIBLIOGRAPHIES

84-2831
Vibrational Analysis in Aerodynamics. 1972 - April, 1984 (Citations from the International Aerospace Abstracts Data Base)

This bibliography contains citations concerned with design and performance relative to aerodynamic vibration. Among the topics discussed are torsion blade flutter; vibration generated by rudders, rotor blades, panels and air foils; vortex shedding; load control; and helicopter gust response flutter. Aircraft vibrational analyses by means of analog computer simulation, auto-flight control systems, and structural dynamics of aircraft are included with consideration for flight vehicle vibration control and reduction. (This updated bibliography contains 157 citations, 13 of which are new entries to the previous edition).

PERIODICALS SCANNED

ACTA MECHANICA
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960 961 552 1803 2294   535 1806 1117 1198 1199
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Helicopter Noise

52	54	465	466	467	468	469
	464		1396	827	848	
			1616	847		
			1926	1927		

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470

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844	55	1976	1618
	845		
	1395		

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290	51	1822	53	844	235	56	1617	1418	489
131	2212	1653	854	845	576	2197	1928	1629	
621	2682		1654	1935	846				
			1874	2175	1656				
			1894	2425	1936				
			2204		2176				

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2179

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1300	2542	983	494	746
2580			1664	1346
				1656
				2196

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830	831	622	293	294	65	66	67	68	69
1400	1401	832	483	484	295	426	1097	1398	1399
1950	1941	1402	623	624	1095	1096	1637	1638	1939
1960	1961	1942	1403	1404	1405	1636	1947	1958	1949
1970		1962	1633	1634	1635	1946	1957	1968	1959
			1943	1944	1945	1956			1969
			1963	1964	1955	1966			
			2433						

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      82 1613 114   1596
                2014

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                 1914 2355   2449

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                      1015
                      2405

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                          935

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1710 2701   1494 325 2326 1727 2708
1810

Impact Force
                1823 2484   2029

Impact Excitation
                2483 1274 105   1698 1219
                          2775

Impact Noise
690

Impact Pairs
                          716 1187

Impact Response									
40	811	342	2043	934	385	356	157	38	839
110	1401	582		2244	935	2036	357	158	1709
650	2241	2042		2254	1295	2156	907	328	2329
810					2155		1917	358	2549
1560						2037	2038		
2030						2157			
2110						2427			

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190 1601 2282 33   2325 186 1177 58
                        1636 1637 1218
                             2427 1278
                                  1638
                                  2438
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2450   1344 1345   7

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2350   1432 2013   2586 1027 2588 159
2750   1902 2063
          2252 2663
          2392

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Interferometric Techniques
2580   2542 953 1664   1656
                          1824

Interior Noise
 820 1621 472   43   44   45 1386 827 468 1619
1920 1931 1922   1374 285   1387   1929
1930 2171 1942   1897
          2162
          2172

Interior Vibration
                                    827

Internal Combustion Engines
1110 351   1573 1574   1276   249
1350

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1760   1393   1575   1987   1069
               2213

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 640 641 642 643 504 855   86   87   88 509
1120 1421 882 1423 1114 1115 876 1997 1208 1119
1800 1801 1422 2003 1424 1685 1686 2467 1998 1999
2000 2001 1582 2603 1684 2095 1996 2557 2228 2229
2711 2451 2002   2444 2465 2466   2468

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1110 851 852 1993   84 2685 2686 497 1668 849
1670   1992   2134   1667   1669
1990   2684   2217

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          2472
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550 2561 112 723 744 665   96 2007 328 549
1470   952 2063 1214 705 136   2238 1209
          2502 2293 1744 1145 386   1439
               2503   2295 736   1499
                         2725   1799
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1130   1572   174 1465   2718 1159
                 1634
                 1764

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2030   2153   2449

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1050   1543 644 2145   2378 2639
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2050 2321 2082 2583 894 1825 2716 2077 708 2079
2080 2801 2572   2424 2585   2797 978 2319
2320   2582   2599
2570   2802

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   use Measuring Instruments

Measuring Instruments
980 981 1522 1243 534 405 976 137 558 1239
1240 2071 1822 1523 984 805 986 577 988 1519
1520 2081   1823 1504 975 2316 977 1238
2800 2581   2803 2234 985 2806 987 2078
     2801   2424 1495   1237 2318
              2584 1825   1837 2798
              2804 2805   2317

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450 441 442 443 444 445 446 447 448 449
600 561

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560   2673 64   77
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2500   1242   1994 1475
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1020 581 972 633 1014 995 1046 397 128 1039
1050 1091 1092 973 1084 1035 1086 557 778 1069
1060 1101 1122 1053 1094 1055 1106 1047 1038 1089
1070 1131 1142 1063 1124 1065 1176 1057 1088 1139
1090 1151 1182 1093 1144 1085 1226 1067 1118 1149
1150 1221 1222 1113 1184 1115 1286 1107 1128 1209
1220 1251 1232 1123 1224 1185 1316 1127 1228 1229
1230 1261 1242 1133 1244 1265 1326 1217 1238 1239
1240 1271 1252 1143 1264 1285 2306 1227 1248 1269
1250 1281 1272 1263 1274 1315 2426 1237 1268 1289
1260 1291 1292 1273 1284 1325   1287 1288 1309
1300 1301 1302 1303 1304 2565   1307 1308 1379
1310 1311 1502 1313 1314   1317 1318 1759
1340 2251 2792 1333 1354   1827 1668 2069
1860 2791   1503 1504   2307 1828 2199
2310   2793 1644   2567 2308 2399
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 320 1591 502   23 674 115 236 1707 1608 649
1150 1721 672 723   235 336 1737 1988 1039
1740 2251 872 813   335 516 2207   1139
2010 2641 1862 1053   1345 526 2577   1259
     2731 2012 1113   1475 656 2717   2219
          2492 1573   1665 1666
               1693   2555 2196
               2713   2396
               2793

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     441   444 445   449
    2511   994 2595   889

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              1984

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1010 211 212 563 404 765 996 747 1008 1009
1280 1011 1002 763 564 1005 1006 1007 2098 1309
     1501 1012 1003 764 1845 1846 1847 2608
     2341 1842 1013 784 2605 2606 2097
     2811 2342 1543 1004   2607
          2812 1843 1024
               2343 1544
               2813 1844
                    2344

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                                   2367

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      40   92   2407 598 2409
     270

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    2181   1983   78
               2413

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              1922   1375 1376   1899

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                    1374   35   1378
                         1505
                         1985

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          372   686 687
                                757
                               2337

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2440 1101   403   1098 309
                                     2678 1069
                                          2679
                                          2709

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 140   91 652   14   2706 1447 728 669
1580 2161 1372   254
1720 2481 2482   1704
2380 2721   2154

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                              1057 2578
                              1267

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          1093 1084   2069

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1230 1071   1085 1086 1227 1228 1089
     1231   1505 1576 1577 2068 1229
                                      1239

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1590 791 792 1053 134 255 2386   17 258 259
     1051 1362 1363 1584 2645   437 788 1359
                              1437 2818
                              1517

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          772   1294
                   2554

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1860   2362

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 320 271 102   23   64   95 336 107   28 649
 490 331 502 213 674 115 516 567   98 1039
1150 661 512 573 944 335 526 997 1448 1139
1430 1591 662 723 1014 665 656 1707 1658 1259
1740 1721 672 813 1044 1345 1666 1737 1738 2249
1790 2251 872 1053 1394 1475 2006 2207 1878
20102351 1442 1113 1444 1665 2196 2577 1988
2490 2501 1713 1273 1684 2245 2396 2717 2208
     2641 1742 1283   2555   2727
     2731 1862 1443   2575
          2012 1573   2705
          2442 1693
          2452 2553
          2492 2713
          2652 2793

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     2531 1172 1173   2026 2527   1619
                            2526

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Noise Generation
  30   51 362 313 1044   65   6   47   8 469
1650 131 522   1604 1425   66 847 828 1459
2630 1351 1062   1634 1765 2446 1167 848 1729
     1651 1572   2634 1995 2656 1377 1728 2469
     2631 2192   2165   2197 2278
                         2635   2377 2638
                                   2637

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Noise Measurement
1390 2081 142   43   54 465   46 137 618 249
2170   892 903 464 905   66 467 978 1389
          1032 1243 2424   976 827   1519
          1622 2413   977

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     1041   52   53   44 1175 466 1607   2659
     1681 472   1174   1396
     1931 522
          1052
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  30 141   12 613 904   35   6 787 688 1459
 350 351 832 1083 1374   45   36 1037 1348 1899
1410 471 1042 1583 1764 155 286 1387 1648 2109
2530 1411 1112 2273 2274 295 626 1457 1898 2639
     1871 1172 2743 2664 315 886 1647 2028 2659
     2171 1252   905 906 2027
          1932   1045 1176 2277
          1972   1375 1356 2747
                        2165 1376
                        2375 1526
                        2665 1766
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                             2656

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820   702   143   1045 1576 1577   138   139
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2590   2409

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770   772   775   769
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2720   2312   873 1144 2285   867 2108 2489
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       452 1023   454   805   606 2157 1008 2159
     1022 1373   604 1065   776   2158
              1595 2136
              2155 2156
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              2595
              2655

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800   421   453   804   266   267 2598 2479
2400   601   2403   456
     801   2513

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         1063   934   605   456   609
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210   121   202   803   24   25   26   457   608   89
810   811   602 1003   884   455   806   807   808   679
     881   802 1753 2094   605 2086 1757   998   989
   2401 1152 2343 2404   885 2366   1038
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30   191   342   813 1914   855   816 1147   88   269
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2160   981 1912 2523   1915 1596 2407   598 2409
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1041 2182   2175 2616   627
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                             2357

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                              1807 868

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                                            2049

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1580 1831 2242 2713 2714 2715   327 1438 659
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1020 1311 1222 233   234   235   236 1217 418 419
1220   1312 473   454   415   416 1307 1088 569
1310   1512 1313   614   485   776 2127 1268 1019
1510   1513 1264   1306   1308 1309
                            2306   2308 1509
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770 1131   1787 1788
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       2511 1022   1754   987 878 269
                    2014   1447 2258 879
                                          2259

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  240   122 123 124 125 126 127 128 129
                    2514 515 486 877 1758 1449
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                         1755 876
                         2005
                         2015

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  680 311 1152 343 344 345 1756 297 378 679
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  660 661 1142 1143 1144 2245 666 1727 868 509
 1140 1141 1442 1723 1284 2495 866 2247 1138 869
 1440 1441 1722 2033 1724   1286 2417 1718 1439
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 2280 1731 2012 2403 2244   1726 2717 2718 2209
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               2434

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2821   1297 768

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                                                       2668

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                                             2116 2117

Reinforced Concrete
 450 161 1432 603 924 605 1146   17 258 439
 640 641 1762 913 934 865 1436 917 438 449
1360 2711 1802 1763 1114 1435 2036 1517 448 599
          2152   1134   1907 928 609
          2242   1364   2157 1778 719
          2392   1594   1698 809
                    2044   839
                                              2009
                                              2019
                                              2089
                                              2369

Reinforced Plastics
          184

Reliability
                         2546   2559

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          2143   1808

Resonance Bar Techniques
                                              979

Resonance Pass Through
1340   173   246 247

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                                              2569

Resonant Bar Technique
    use Resonance Bar Technique

Resonant Cavities
    use Cavity Resonators

Resonant Frequencies
 2011 2502 493 1294 1875 1716   658 579
          1433   2719

Resonant Response
120 271 2732 1663 2214 2205 2206 2407 898 879
 1731   2589
 2451

Resonators
               1824   556

Response Spectra
2100   202   979

Restoring Factors
                                        2438

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    891

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               2754

Reverberation Chambers
               2025 2276   698

Reviews
 620 431 2582 173 1344   55   76 257 108   19
1570 1611   243 2564 155 116 907 638 559
     1931   453   1695 196 947 1548 719
     2381   533   2625 476 1567 1688 2289
     2421   933   796 1987 2308 2769
                1983   946   2688
                2213   1466
                2293   2166
                              2506

Ride Dynamics
1380 2411 612 823 2414 1605   2327 818 1379
                    2624   2829

Rigid Body Modes
                         1245

Rigid Foundations
          1863   2647

Rigid Plastic Properties
                              357 358 1299

Rigid Rotors
    761   2134

Rigid Wall Ducts
          1452   1454

Rings
               1743 634 875 1446 677   359
                     874 2435
                    1744
                    2464

Ritz Method
1700 2501 2492   1705 1666   2648

Riveted Joints
          1582   504

Road Tests (Ride Dynamics)
    use Ride Dynamics

Roads (Pavements)
    1061 1372

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Safety Restraint Systems
1600　31　32　33 2114 2115 2116 1937 1918 1919
1960 1601　　2113　　　　　1967 1968 1949
　　　　　　　　　　　　2117　　1969

Sand
　　1371　　　263　　　　　1906 1027　　　929

Sandwich Laminates
　　use Sandwich Structures

Sandwich Panels
　　use Panels and Sandwich Structures

Sandwich Structures
　　　　　664　　　1496　　　508 1739
　　　　　　　　　2006

Satellite Antennas
　　use Spacecraft Antennas

Satellites
　　1221　　　　　　　　　2177

Saws
　　　1183　　　　　　2637 2638

Scaling
　　　　　　　　2807　208　449
　　　　　　　　　　　　　　2089
　　　　　　　　　　　　　　2329

Screening
　　　　　　　　　　　428　429

Seals
　90 2231 2232 2233 2234　245 2696　317 1688 1429
2230　　　2813　　　2675　　1687　　1689
　　　　　　　　　2695

Seat Belts
　　1321　　　33　　2115

Seats
　　1911　　　1974

Seismic Analysis
　410　161　22　363　　　215　496　437　258　259
1060　421 1762　803　　　345　606　　　2158　439
1450 1151　　2023　　　　1246　　　2548　679
2260 2361　　2283　　　　　　　　　　1059
2370 2391　　2393　　　　　　　　　　2149
　　　　　　　　　　　　　　　　　　2159

Seismic Design
1360　261　362　133　114　805 1566　797 1058 1359
1590 1121　782　203　794 1065 2186 1357 1588 2369

(cont'd)

Seismic Design (cont'd)
2100 2261　932　343　884 2655 2386 1437
2760 2391 2702　933 1584　　　　　2247
　　2711　　2513 2394　　　　　2807
　　　　　2703 2404

Seismic Excitation
　640　121　　　413　　　　　26 1587 1128 1589
　790　641　　　523　　　1756　　　1368 2709
1270　891　　2383　　　　　　　　　　2729
　310　　　　　　　　　2186

Seismic Response
　260　311　452　133　334　265　336　297　678 1469
　310 1031　592　263　594　595　596　597　798 2259
2520 2741　602　603　604　605 1436　717　808 2479
　　　　1532　833　834　805 2286　807 1468 2519
　　　　1592 1363　994　815 2546 1467 2148 2759
　　　　2242 1373 1114 1595　　　1757
　　　　2312 1763 1534 2135　　　2047
　　　　1903 1904 2265　　　2547
　　　　　　2264 2285
　　　　　　2284
　　　　　　2384
　　　　　　2644

Seismic Response Spectra
　　　　　202　933　　　　　2807　　　259

Seismic Tests
　　2521　　　　754　　　266　　　　2629
　　　　　　　2264　　　806

Seismic Waves
　　1471　　　1214 1825 1566
　　　　　　　　　　1856
　　　　　　　　　　2066

Self-Excited Vibrations
2050 2751　　　　　　　2687　938
　　　　　　　　　　　　1428
　　　　　　　　　　　　2738

Semiactive Isolation
　　　　　　　　　2443

Sensitivity Analysis
　　　　　　　　2306 2127 2129

Servomechanisms
1490

Shafts
　580 1331　432　　3 2374 1335　786 1007 1338 1569
1330 1341　862　863 2464 1805 1036 1327 1418 2129
1570 1571 2132 2463　　2135 1886 1877 1878 2139
2130　　　　　　2335　　　2128
2140

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Sound Waves
330	521	462	683	144	105	696	147	708	149
520	691	692	693	154	695	706	697	1148	699
690	701	902	703	354	705	886	707	1158	869
700	711	1162	743	694	1145	1166	1157	1168	889
710	901	1252	1153	704	1165	1816	1457	1748	1159
970	971	1452	1162	744	1465	2026	1647	1768	1169
1160	1161	1462	1213	1104	1715	2516	1727	1818	1739
1170	1361	1772	1453	1154	2275	2536	1777	2518	1769
1640	1451	2532	1463	1164	2515		2267	2588	2269
1770	1461	2742	1703	1454	2755		2517	2728	2749
2750	1771		2263	1464			2737	2748	
	2751		2533	2364					
			2723	2534					
			2733	2744					
			2753	2754					

Spacecraft
60	2351	482	933	204	1085	1086	1087	1088	1089
1120		1092	1093	1084	1105	2426	1287		1539
1940			1303	1194			1397		2429
2430			2323	1244			2307		
				2674					

Spacecraft Antennas
61	62		1088
	292		1118
	2432		

Spacecraft Components
1130	63		207	2088
	513			2558

Spacecraft Equipment
1632

Spacecraft Equipment Response
63	2428	59

Space Shuttles
1090	1091	513	1094	995	2456	57	58	829
2431			2454	2455		2427	2178	
						2457		

Fatigue Life
950	211	312	543	24	185	86	377	28	539
1190	381	542	853	544	535	376	587	378	949
1200	541	942	1103	564	1135	476	687	548	959
1280	951	952	1193	954	1195	536	957	588	1189
1380	1191	1082	1203	1194	1205	736	1197	878	1199
1680	1201	1192	1423	1204	1365	956	1207	948	1469
1800	1391	1202	1493	1314	1495	1006	1497	958	1489
2000	1421	1492	1603	1384	1795	1196	1677	1188	1499
2060	1491	1582	1643	1424	1805	1206	1797	1198	1679
2160	1801	1802	1793	1494	1935	1496	2057	1208	1799
	2001	2002	1803	1754	2295	1886	2447	1468	1999
	2061	2062	2063	1794	2455	2056	2457	1488	2059
	2211		2203	1804		2456		1498	2379
	2431			1934				1798	2409
				2294				2058	
				2454				2228	

Specifications
	754		2538

Spectral Analysis
    use Spectrum Analysis

Spectrum Analysis
221	242	363	974	2305	1826	197	1508
1131	2192		1064			1507	2448
2571			2354				2578

Spectrum Analyzers
192	977

Spheres
970	1136

Spherical Shells
670	513	2013	1734	675	1737	339
	2252	2253				

Spindles
420
1050

Sports Equipment
1250

Spring-Mass Systems
    use Mass-Spring Systems

Springs
71	842	1106	629
			1409
			1649
			2679

Spur Gears
1682	503	2225
	1113	

Squeeze Film Bearings
2221	2222	373	1418
2462	2223		

Squeeze Film Dampers
2221	182	373	485	1418
		533		

Stability
291	232	1073	104	885	216	407	2768	2649
671	2122		2134	2425	726	2167		2769
1111	2822		2734		1186	2237		
2121					2416			

Stability Analysis
    use Stability

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   1181

Stage Separation
   60   59

Stalling
1880 1781 1882 1783 1784 2545   2767
2550 1881   1883

Standards
   use Standards and Codes

Standards and Codes
1870 761 782 2113 424 425 426 437 2628 2369
   1871 1062   2114 2115   1927   2629
                  2415   2627

Start Up Response
                                    936

State Space Approach
                          1046   1978

Statistical Analysis
      381   414 915 366
                     774   2206

Statistical Energy Analysis
   230   773   518

Statistical Energy Methods
   111 472

Statistical LInearization
                          2126

Steady State Excitation
   use Periodic Excitation

Steady-State Response
   use Periodic Response

Steam Generators
   use Boilers

Steam Turbines
   1011 1012 2203   1055 1066 587 588 1009

Steel
   380 1191 2002 253 1794 375 536 537 958 2059
1200 1201   813 2034 1375 1836 1557 1188 2379
2000 1591   1803 2044 2015   2057 1498
2060 2001   2033 2784 2435   1758
      2061   2523   2058
              2783   2498

Steering Gear
   610   1096   1979
1100

Steering Wheels
   use Steering Gear

Step Relaxation Method
1130

Stick-Slip Response
                                    716

Stiffened Plates
                          1724 1725

Stiffened Structures
                          2714

Stiffener Effects
1150   2007

Stiffness Coefficients
      2201 1672 583 1674   2136 2227   1109
           2132 1563   1609
           2442 1673

Stiffness Effects
   940   942   496
             1682

Stiffness Methods
                          1133

Stingers
      2322

Stirling Engines
   90   422

Stochastic Processes
1180 451   1333 594 2305   2598 1059
      751   2024 2615
      791   2614
                    2824

Storage
                                         1909

Storage Tanks
                    114   2247   2729

Strain Gages
   use Strain Gauges

Strain Gauges
             1223 1224

Strain Rate
2540

Strains
             1224

145

Stress Intensity Factors
                    1807

Stress Waves
2700   982   172o   739
                                           1849

Strings
1430   91   2004 2235   2697 2828   19
1690 1691
2470 2471

Strips
  2721

Structural Components
    use Structural Members

Structural Damping
            374   509

Structural Design
  1021

Structural Elements
    use Structural Members

Structural Members
  2111 1582 1763   1805   838 889
  2522 2523   929

Structural Modification Techniques
  1252 1253 584 1255 526 1247 1248 1069
  2612 1323 1254   1256 1257 1258 1139
  2772 2613 1324   1317 1858 1249
                       2127
                       2557

Structural Response
  911   2385 2536

Structural Synthesis
  1514

Structure-Borne Noise
  660   2514 515
  1930

Struts
              1416

Studded Tires
              2446

Subharmonic Oscillations
  2692   176 2407

Submarines
          2466   2508

Submerged Structures
  510 521 412 163 154 2245   1127 148
       872 213   2555   2727 208
       2702 2703   778
                                        2728

Substructure Coupling
    use Component Mode Synthesis

Substructuring Methods
  490   972 1573 1514 555 566 397 2108
             2303   1345 1246 1247 2818
                           2575 1256
                           2736

Subsynchronous Vibration
                2266   1879

Successive Approximation Method
                255

Successive Transformation Method
                181

Supports
  2260   1002   1744 345 1756 2257   1099
                          755   2437
                          2015
                          2595

Surface Roughness
          1602   2794   936   499
          1992

Surges
                1414 585 586   629
                           1556   819

Surveys
    use Reviews

Suspended Structures
                2473   1106

Suspension Bridges
  2380   592

Suspension Systems (Missiles)
                            77

Suspension Systems (Vehicles)
  80 631 822 1103   75   76   78 1409
  630 841 1642 1643   1485   1408
  1070 1981 1872 1983   1558
  1980 2181 1982 2443
  2180 2441 2442
  2680 2681

Swept Sine Wave Excitation
1397

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use Proceedings

Synchronous Motors
687

Synchronous Vibration
2796   348

System Identification
2791

System Identification Techniques
241   1253   775 416 417 258
1511   1513   1025 776 1397 2148
1857

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Tailpipes
128

Tanker Ships
38

Tanks (Containers)
340   513 334 1445   2729
873   2245
2013

Taxiing Effects
231

Telemetry
1664

Temperature Effects
331 1832 103 1754 25 696   548 949
1441 2432 183   2055 2726   738
2512 2493   2495   868
1708

Tennis Rackets
use Sports Equipment

Test Data
use Experimental Data

Test Equipment and Instrumentation
1490 561 2322 953 734 545 546 207 1528
1531   1504   2326

Test Facilities
780 2591 992 1833 914 995 206 917   239
1760   1094 1525 1526 2087
1204 1835 2806
1244 2085
1524
2324
2674

Test Fixtures
use Test Facilities

Test Instrumentation
use Test Equipment and Instrumentation

Testing Apparatus
use Test Equipment and Instrumentation

Testing Equipment
use Test Equipment and Instrumentation

Testing Instrumentation
use Test Equipment and Instrumentation

Testing Machines
use Test Equipment and Instrumentation

Testing Techniques
830 871 872 2313 1244 405 186 617 1048 189
1330 1451 1132 883 204 1315 616 1447 1528 269
1450 2301 2282 993 1534 1385 1316 547 1678 1429
1650   41 2592 1533 1834 615 2316 897 1838 1439
2310 991   2593 1984 745 686 1227 2538   59
1600 2541   915 1946 2597 2628 189
1840   1525 2076 2627   1649
2210   1685 2596   1839
2325

Textile Looms
1765   2278

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use Spindles

Theory of Adaptive Identifiers
2353

Thermal Excitation
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800

Thermoelasticity
2104

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use Geometric Effects

Tilt Pad Bearings
583   2218
                       2688

Time Delay Spectrometry
400

Time-Dependent Excitation
2720   1443   648 329
          2403   728 1299

Time-Dependent Parameters
221   94 2305
                  2675

Time Domain Method
440 21 282 393 1264 695 1306 1227 78 2819
520 201 772 1253 1654 1085 1546   388
840 231   2333   2576 2618
1370 1311   2666
1520 2181
2370 2791
2620

Time Series Analysis Method
1290 1281

Timing Devices
                   2118

Timoshenko Theory
2030   633 1704   658
          1714   1708
          2704

Tire Characteristics
823 1984

Tires
632 633 1984
1602 2193

Tools
              298

Torque
671 2082   784   1877

Torsional Excitation
              687   329
                       1549

Torsional Response
2350 2682 523 324 15 2226 507   1589
      1353 2384 785

Torsional Vibrations
1570   91 432   3 1565 1006 2008 649
2080 1431 642 73 1875 1876   1339
1721 1352 113   1995   1419
1901 1702 1683   2575   1479
          2003   2009
          2463   2599
          2693

Torsional Waves
1212

Towed Bodies
use Towed Systems

Towed Systems
2663   269

Towers
20   21 262 273 1364 2645 2387 18 19
260 1591 272   1914   2407 598
2160   812   2504   1128

Tracked Vehicles
1981   2163   189

Traction Drives
2441 2442

Tractors
610 611 612 1353 254
2050 1911
2180
2680

Traffic Induced Vibrations
                          528

Traffic Noise
142 483 1174 1635 1377 2528
462 623 1774
1172 1173
1243

Trailers
1382   254   1377
        1604
        2414

Trains
use Railroad Trains

Transducers
401   2073 1234 1235 1516 1517 1518 2799
581   1845 2586 2587 2588

Transfer Functions
1573   2278 249
              2319

Transfer Matrix Method
1731 1372   1285   1738 879
                 1565

Transformation Techniques
181   1287

Transient Analysis
        1735 1016
        2525

Transient Excitation
        1232   1984   936 2167

Transient Response
2720 231   233 2304 725 1026 1337 368 319
     241   433 2724   1567 728 1549
2611   753   2657 2818 1889
              1023
              1323
              1383
              2623
              2773

Translational Response
        1445

Transmissibility
    use Transmissivity

Transmission Lines
        1692   1124   2236   18 19
                            2476

Transportation
    use Transportation Vehicles

Transportation Effects
        806   2439

Transportation Systems
    use Transportation Vehicles

Transportation Vehicles
        2473   76

Transverse Shear Deformation Effects
870 1701 322 653 1734 2705 96 507 318 99
1730 2731 652 673 2484   866   328 2189
         1723   508 2509
                                    858

Trees (Plants)
        1457

Triangular Bodies
    101

Truck Tires
        633

Trucks
        831 612 293 294 1385 1606 1377 1308
            1472 613 1384
            1942 1103 1604
                 1643

Trusses
        323

Tube Arrays
2510 2401 2262 883 1434   116 1827   2739
                    2704   2016 2017

Tubes
1750 341 882 303 304 305 86 87 88 149
2740 401 1422 883 514 885 306 1747 1748 1749
     1751 1752 953 1424 1745   2027 2478
              963   2515   2237 2738
              2523   2737

Tuned Dampers
              1486 1247

Tuning
410 491 492   3 2214 1415 1336   1108 1139
        2202 333   2205 2206

Tunnels
        1593 2394
        2393

Turbine Blades
1660 81 2362   494 2205 2196 1657 1658 1659
2200 2201 2452   2214 2455 2206 2457 2208 2449
2210 2211   2454   2456
2451

Turbine Components
        1012   2155 2156

Turbine Engines
        2272

Turbines
    431   2   5   1277   2579
    2341 2142   1055

Turbofan Engines
1860   2632 1393 2634   128
             2743

Turbofans
        2743

Turbogenerators
1010   2122 2123   2129
2140   2132
2150   2152
        2332
        2342

Turbojet Engines
2558

Turbomachinery
1420   1662 2133   4 1035 1336   7 248 1879
        2292 2633 784   317 2138 2139
             2344

Turbomachinery Blades
    use Rotor Blades (Turbomachinery)

Turbulence
100 2631 352 2353   5 1076 847 1178 899
900   2682 2753   2765 2766
    2752

Two-Degree of Freedom Systems
725

Two Microphone Technique
1520 751   903 514
2570 1831   2583 2024
        2574

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Ultrasonic Techniques
980   993   1685 876 877 988 989
990   2603   2417 1518 1839
1840

Ultrasonic Tests
    use Ultrasonic Techniques

Ultrasonic Vibration
           1686 2587 2588 2079
           2496

Unbalanced Mass Response
430 1   2 2463   1327 1328 1329
2130 581   2218 2219
    2131

Undamped Structures
          664   368
                  2568

Underground Explosions
600   922   1908 929
910
2040

Underground Structures
450 441 442 443 444 445 446 447 448 449
1450 921 2392 1593 924 865 796 1447 1908 1909
         2393 1594 2475   1907
         2394

Underride Guards
    use Guard Rails

Underwater Explosions
          2543 164 165 2466   159
                        169

120 2511 342   2014   987   119

Underwater Sound
150 521   1163 1164 145 146 147 708 709
710 711   1463 1464 705 706 707 1168 1169
1170 971   2364 895 896 1777 2078
1820   2534 1465 1466 2367 2268
          2764 1775 1776   2728
              2756

Underwater Structures
2250 511 872 163 1104 855 856   27 488 1029
2410 981   2663   987   2719

Unified Balancing Approach
2338

Universal Joints
2125

Urban Noise
141   2528

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Valves
311   315 316 1427 1428 89
421   505 1426   2469
          1425

Vanes
    1662   2635   2377

Variable Amplitude Excitation
87

Variable Cross Section
2190 331 672   104   95 866 1707 1718 109
    2701   1125 1666 2707 2018

Variable Material Properties
2480   723

Variational Methods
1740 411   1284   216 407
                 226

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    2536

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    353

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    use Ships

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    1905   1057 678

Vibration Absorbers
    use Vibration Absorption (Equipment)

Vibration Absorption (Equipment)
    73   74 1755   489

Vibration Analysis
```
2450  101  282  223   94  635  576  397  198  199
2510  671  772  843  104 1985  726  407  508  779
2580  721 1682 1723 1284 2405 2106  647  578 2679
      871 2222 1853 2554 2505 2166  677  748 2769
     1921 2712 2133 2714 2725 2576  747 1338
     2121      2153               1987 1478
     2471      2213               2137 2238
                                 2487 2718
                                 2577 2808
                                 2697
                                 2707
```

Vibration Control
```
290 1101  482  373  244   55 1646 1087   18 1349
610 1441  722 1043 2374  135 1976 1487  178 1579
2430 1911 2372 1343      845 2136 1977 1618 2169
2051      2493      1105 2236 2277 1898 2429
2691               1455      2397 2398
                   2215
```

Vibration Dampers
    2558

Vibration Damping
470   292 183 534 1375   1487   1069

Vibration Detectors
    2798 2799

Vibration Effects
    435 426

Vibration Excitation
```
830      902  293  294            68   69
    2762 1473  484              458
    1633
```

Vibration Frequencies
870   1719

Vibration Generation
    2638 2469

Vibration Isolation
70   1972 1973 2464 835
    2182

Vibration Isolators
    533   2187 298
    2678

Vibration Measurement
```
2071  482      1664  405  746  477   48  579
2080 2321 1522       905 1346       478
     1892           1225 2576       528
                        2716
```

Vibration Meters
2071

Vibration Monitoring
    747

Vibration Prediction
2051   1034   117
    1944

Vibration Probes
    2584

Vibration Recording
1652

Vibration Reduction
    use Vibration Control

Vibration Resonance
    use Natural Frequencies

Vibration Response
```
940  111 1002  103       325  786  527 2358  459
1330  941           1575 1786  817
1710 1021                 2317
```

Vibration Signatures
    2579

Vibration Source Identification
1331   2143

Vibration Spectra
    use Vibration Response Spectra

Vibration Tests
```
800      2322   23 1524  175  206   17  438   49
1660     2792 1833 1904 1525       127 2428  189
         2323      2415       267 2438  239
                             1147       559
                             2087      1479
                                       1609
```

Wave Energy
1102   799

Wave Equation
901   2004

Wave Forces
2410   412   414 1615 816 37 28 119
                           814 1915   1147 2168 269
                           1914 2395   2387 2408 799
                           2014   2488

Wave Generation
902 1463
2533

Waveguide Analysis
1640   2298 2269

Wave Makers
1211

Wave Number
use Frequency

Wave Propagation
350 691 692 693 154 105 346 707 1168 149
700 701 1252 963 394 705 1696 737 1748 699
710 901 1772 1153 554 1215 1816 1557 1768 739
1030 1211 2302 1213 714 1465 2516 1727 2518 969
1210 1451 2532 2263 964 1815   1747 2648 1169
1470 1471   2543 1154 1825   1817 2748 1769
1720 2281   2723 1214 2005   2007 2758 1849
1770 2561   1464 2515   2267   2269
2330 2701   1704   2477   2279
2700   1814   2517   2749
                    2534   2537   2789
                    2744   2757

Wave Radiation
690   2742 1703   1145   1157 1148 869
                        2535   1777 2518 889
                        2755   2588

Wave Reflection
971 462 1413 144 1145   1768
1771   1593 504 2275
          704
          1164

Wave Scattering
390 391 392 393 174 415 696 967 188 1159
520 521 742 553 354 695 966 2737 388
970 741 1162 743 554 1165   968
1170 1161   2733 694 1715   1818
          2753 704   1838
               2364   2298
                              2728
                              2778
                              2788

Wave Transmission
1361   504 1145   708 1739
2301   744
               1454

Weapons Effects
2041 2112 923 2044 915 916 917
                    2536

Weapons Systems
2042 2043

Wear
940 2681 942 2683 84 435   248
                                      1998

Wedges
                              1166

Weighing Systems
                                   2317

Welded Joints
380 2001 2002 1423 644 1685   86   87 1208 1999
2000   2603   2095 516 877   2229
                                    876 2497

Welding
               1005

Wheelchairs
1600

Wheels
1410 1411 632   634 1985   2447   2189
1650 1651
2190
2810

Whipping Phenomena
                                   2508

Whirling
2371   1675 1676   7 1328 2709
                    2685 2686   2128

Wiegand Effect Sensors
                                   2798 2799

Wind-Induced Excitation
50 1031 262 943 574   15 256 257 788 599
1051 792 1163 1054 495 1076   1128 2009
2381 1392 2383 1364 2645 2556   1358 2359
2591 1692 2643 1784   1628
     1912
     2022
     2382
     2522
     2552

Wind Tunnel Testing
280   262 403 474   85   1617   48   49
2280   1342   755   1358 569
         2532

Wind Tunnel Tests
    use Wind Tunnel Testing

Wind Tunnels
    2591

Wind Turbines
         1572   5   1537

Windows
                              2538

Wing Stores
    2671 2422   1624   616

Winkler Foundations
         1592

-X-

X-Ray Techniques
    2092

-Y-

Yarns
                1765

-Z-

Z-Transform Method
1310

CALENDAR

JANUARY 1985

22-24 Annual Reliability and Maintainability Symposium [IES] Philadelphia, PA *(IES Hqs.)*

28-31 3rd International Modal Analysis Conference [Union College] Orlando, FL *(Ms. Rae D'Amelio, Union College, Wells House, 1 Union Ave., Schenectady, NY 12308 - (518) 370-6288)*

29-Feb 1 International Conference on Nondestructive Evaluation in Nuclear Industry, Grenoble, France *(J.P. Launay, COFREND, 32 Boulevard de la Chapelle, 75880 Paris Cedex 18, France)*

FEBRUARY 1985

25-Mar 1 International Congress and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1985

18-21 30th International Gas Turbine Conference and Exhibit [ASME] Houston, TX *(Intl. Gas Turbine Ctr., Gas Turbine Div., ASME, 4250 Perimeter Park South, Suite 108, Atlanta, GA 30341 - (404) 451-1905)*

APRIL 1985

1-3 2nd International Symposium on Aeroelasticity and Structural Dynamics [Deutsche Gesellschaft für Luft- und Raumfahrt e.V.] Technical University of Aachen, Germany *(Symposium Organizing Secretariate, Deutsche Gesellschaft für Luft- und Raumfahrt, Godesberger Allee 70, D-5300 Bonn 2, W. Germany)*

8-12 Acoustical Society of America, Spring Meeting [ASA] Austin, TX *(ASA Hqs.)*

15-17 Institute of Acoustics Spring Conference [IOA] York University, UK *(IOA, 25 Chambers St., Edinburgh EH1 1HU, UK)*

15-19 2nd Symp. on Interaction of Non-Nuclear Munitions with Structures [Tyndall AFB, FL; Eglin AFB, FL; Kirtland AFB, NM] Panama City Beach, FL *(Ms. L.C. Clouston, Registrar, P.O. Box 1918, Eglin AFB, FL 32542 - (904) 882-5614)*

22-26 International Symposium on Acoustical Imaging, The Hague, The Netherlands *(J. Ridder, P.O. Box 5046, 2600 GA Delft, The Netherlands)*

29-May 3 31st Annual Technical Meeting and Equipment Exposition [IES] Las Vegas, NV *(IES Hqs.)*

MAY 1985

6-8 4th International Symposium on Hand-Arm Vibration [Finnish Inst. of Occupational Health] Helsinki, Finland *(I. Pyykko, Inst. of Occupational Health, Laajaniityntie 1, 01620, Vantaa 62, Finland)*

6-9 American Society of Lubrication Engineers, 40th Annual Meeting [ASLE] Las Vegas, NV *(ASLE Hqs.)*

22-24 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] New Orleans, LA *(Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)*

JUNE 1985

3-5 NOISE-CON 85 [Institute of Noise Control Engineering and Ohio State University] Columbus, OH *(NOISE-CON 85, Dept. of Mech. Engrg., Ohio State Univ., 206 W. 18th Ave., Columbus, OH 43210 - (614) 422-1910)*

24-26 2nd National Conference and Workshop on Tailoring Environmental Standards to Control Contract Requirements [IES] Leesburg, VA *(IES Hqs.)*

JULY 1985

2-4 Ultrasonics International '85, Kings College, London *(Z. Novak, Ultrasonics, P.O. Box 63, Westbury House, Bury St., Guildford, Surrey GU2 5BH, England)*

11-13 International Compressor Engineering Conference, Lafayette, IN *(Purdue University, W. Lafayette, IN - (317) 494-2132)*

AUGUST 1985

5-10 SAE West Coast International Meeting [SAE] Portland, OR *(SAE Hqs.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and
Astronautics
1633 Broadway
New York, NY 10019

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASLE: American Society of Lubrication Engineers
838 Busse Highway
Park Ridge, IL 60068

ASME: *American Society of Mechanical Engineers*
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

ICF: International Congress on Fracture
Tohoku University
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IMechE: Institution of Mechanical Engineers
1 Birdcage Walk, Westminster,
London SW1, UK

IFToMM: International Federation for Theory of
Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
67 Alexander Dr.
Research Triangle Park, NC 27709

SAE: Society of Automotive Engineers
400 Commonwealth Dr.
Warrendale, PA 15096

SEE: Society of Environmental Engineers
Owles Hall, Buntingford, Hertz.
SG9 9PL, England

SESA: Society for Experimental Stress Analysis
14 Fairfield Dr.
Brookfield Center, CT 06805

SNAME: Society of Naval Architects and Marine
Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Laboratory
Code 5804
Washington, D.C. 20375

PUBLICATION POLICY

Unsolicited articles are accepted for publication in the **Shock and Vibration Digest.** Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings and reports of a pertinent topic in the shock and vibration field. A literature review should stress <u>important</u> recent technology. Only pertinent literature should be cited Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .

The format and style for the list of References at the end of the article are as follows:

- each citation number as it appears in text (not in alphabetical order)
- last name of author/editor followed by initials or first name
- titles of articles within quotations, titles of books underlined
- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- volume, issue number, and pages for journals; publisher for books
- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).

2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., <u>Aeroelasticity,</u> Addison-Wesley (1955).

3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Dev. (1962).

4. Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).

5. Landahl, M., <u>Unsteady Transonic Flow,</u> Pergamon Press (1961).

6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).

7. Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).

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